A ~~FACTOR ANALYTICAL AND~~ LONGITUDINAL STUDY OF CAUSAL THINKING IN BRITISH MIDDLE SCHOOL CHILDREN

by

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"Man is a cause-seeking creature; in the spiritual order he could be called the cause-seeker. Other minds perhaps think things in other - to us inconceivable - categories."

George Christoph Lichtenberg
(1742-1799)
Aphorismen

ABSTRACT

A multiplex view is taken of causality, and childrens' causal thinking, which is based on current scientific views, Piagetian theory, and the author's interpretation of childrens' causal explanations during the pilot studies. An instrument, devised by the author, for the categorisation and measurement of causal explanation as a means of assessing childrens' causal thinking, is a central feature of this investigation. The instrument is called the Physical Causality Test Battery (PCTB)

A sample of 112 middle school children aged 9 - 10 years were investigated in the context of two guiding statements.

The first statement included research problems and hypotheses directed to a study of the nature of childrens' causal thinking and its possible relationships with other abilities. One hundred and two out of the 112 children were tested in this part of the investigation.

Application of Factor Analysis using a Varimax Rotational Solution indicated that 5 extractable factors emerged. Factor 1 reflected childrens' appreciation of practical causal contexts. Factor 2 indicated a strong element of general achievement as measured by standardised tests. Factors 3 - 5 mainly embraced causal creativity, initial and pluralistic causal components respectively.

A one way analysis of variance treatment, indicated only qualified support for Piaget's position on the relationship between causal and operational thinking.

The second guiding statement included research problems and hypotheses related to testing an aspect of causal thinking in the 112 children. Eighty of these children were tested on 3 separate occasions at 7 monthly intervals. A further sub-group of 32 Ss were drawn to test for practice effects. A Two Way Anova mixed design (repeated measures), showed highly significant results for between Subjects and within Subjects sources of variation. However, this treatment did not indicate sufficiently small group or individual trends. In response to this, the author devised a descriptive technique termed, Modal Pattern Analysis (MPA), which aimed to detect and monitor change in childrens' causal explanation over time. The application of MPA in the context of a 3 test longitudinal design, revealed four modal patterns, (i.e. linear, progressive, regressive and erratic) to childrens' causal explanations.

Childrens' modal patterns appear to be influenced by the nature of the stimulus material, and certain experiential factors. However maturational, mnemonic and motivational processes are likely to be involved.

Case studies of causal stimulus items, and studies of individual children showing distinctive modal patterns are discussed.

Finally, educational implications and suggestions for further research arising from this study are outlined.

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LIST OF ABBREVIATIONS USED IN THE THESIS

C	=	Cause
Ef	=	Effect
MPA	=	Modal Pattern Analysis
N	=	Number of Subjects
PCTB	=	Physical Causality Test Battery
S/s	=	Subject/ s
X	=	Experimental Treatment

CHAPTER 1

INTRODUCTION

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Psychological research into causality has had a somewhat erratic history, since Piaget (1930) first put forward his observations on how children explain the causes and effects of certain physical phenomena e.g. cloud movements, the bicycle mechanism etc.. Following on from this early work of Piaget, there were a number of studies in the mid 1930's and early 1940's, that were replicative in nature and which either challenged Piaget's original position [Isaacs (1930) Deutsche (1937)] or supported his findings Dennis (1943). These early studies concentrated mainly on young children between the ages of 3 - 8 years exploring pre-causal notions and explanations of causality. One particular area being that of animistic thinking. The late 1940's and 1950's were fairly barren in any further study of causality until the work of [Laurendeau and Pinard (1962)]. However, their research also concentrated on pre-causal notions, which included an elaborate emphasis on the Piagetian stage concept, under which causality as a notion was subsumed under the stage theory.

Even towards the end of the 1960's, the work of Berzonsky (1969) while employing interesting factor analytic approaches, to the possible relationships between causal thinking and other reasoning and operational propensities, still concentrated on relatively younger children. More recently, research into causal thinking has been extended to cross cultural settings [Acuña (1980), Thomas (1979), (1981a)], to social causality [Whiteman (1976)] and to more extended areas of physical causality e.g. plurality and the role of attribution theory [Kelley (1973), Schultz and Mendelsohn (1975), Seigler (1975)]. Also in the 1970's, Piaget has examined the development of understanding causality through various experiments related to memory [Piaget and Inhelder (1973)] and to operational thinking [Piaget (1974)]. Both these later areas of Piaget's work have significance for this investigation, in that causal thinking and its relationship to operational thinking and other abilities are the concern of the first part of the thesis. The second part, examines changes which occur in causal explanation over a specific time, and therefore involves memory processes.

The selection of the above areas for investigation, was based on the fact that the study of causal thinking is an under-researched area of cognitive development, especially in the older primary school child. Moreover, no substantial study has been carried out in British schools on causal thinking and its development, especially in the context of a longitudinal design. Therefore, it seemed particularly apt to examine the development of causal thinking within the age range covered by the relatively recent middle school system. The idea behind the middle school was born in the early 1960's, and was seen as an essential bridge but equally important separate component of a three tier comprehensive educational system. The local authority schools in which the present research reported here was carried out, included children aged from 9 - 13 years. This system was set up in the late 1960s, and it was stressed by the local education authority, that causality among many other notions should be given a greater amount of focus by teachers in their teaching.

It appears therefore, in selecting the area of causal thinking for a detailed study especially in the middle school; one is first of all exploring the processes related to causal appreciation at an older age range, and secondly in part of the school system which has had less than its share of attention to cognitive developmental research. In addition to these points an important part of this study examines changes in the development of causal thinking in the same Ss over time, and so a much needed longitudinal perspective, has been included in this investigation.

From the standpoint of the science curriculum, the study of causal thinking is of crucial importance, as it forms an important area in the child's ability and experience to explain and answer many causal situations encountered in and out of school. In a wider context, the study of causal thinking has applications and implications for other curriculum subjects e.g. social studies, history, geography. So, taken all in all, the study of causal thinking in the middle school child is not only well grounded psychologically, but of vital concern in the application and implications such a study may have for the whole school curriculum.

PART ONE REVIEW OF THE PERTINENT LITERATURE

CHAPTER 2

PHILOSOPHICAL AND SCIENTIFIC PERSPECTIVES TO THE STUDY OF CAUSALITY

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Introduction

The long history of the causal principle shows how it has been fashioned, adapted, disguised, reinterpreted and sometimes considered by some as quite unnecessary. It is the aim of this chapter to trace briefly, the historical development of the principle, and eventually to discuss and establish for this study its modern interpretation. As a result, it is hoped that this study of causal thinking in children will have the benefit of a firm philosophical and scientific basis.

The chapter will be divided as follows:-

2.1 A brief examination of the early historical development of the causal principle.

2.2 The Development of the Modern conception of the causal principle.

2.3 A consideration of selected Aspects and Alternative Interpretations of the Causal Principle, with special reference to the present investigation.

Before embarking on the first section it would be useful to clarify the threefold meaning of Causality. Causality has three principal meanings. Firstly it is used to designate a category i.e. a causal bond or connection or nexus. In this sense it is known as causation. Secondly, it is used in the form of a statement or law of causation, i.e. a causal principle "the same cause always produces the same effect or similar statement.

Finally, causality may be used in the sense that it is a doctrine i.e. causalism, that which holds the universal validity of the causal principle, to the exclusion of other principles of determination.

While all three meanings will be alluded to in the discussion that follows in this and other chapters, it is the first and second meanings that will receive the most attention. The reason for this, is that in a study of causal thinking, it is necessary to know the nature of causation and what general laws hold for the process, in order that valid research questions can be formulated, and effective instruments for measuring causal appreciation can be constructed.

2.1 A Brief examination of the early historical development of the Causal Principle

It was Aristotle who elaborated Plato's somewhat diffuse ideas concerning the causal principle and codified it into four causes, namely, Causa materialis - referring to material on which causes act; Causa formalis - which contributes to ideas etc.; Causa efficiens - which is a motive force or external influence and finally Causa finalis - a goal to which everything strives.

By the seventeenth century, the Aristotelian conceptions of causality were whittled down to Causa efficiens at the time modern science was beginning to develop.

Galileo defined the Aristotelian conception of Causa efficiens in terms of necessity and sufficiency, but his view while satisfying ontological inquiry (i.e. probing the origins of cause), could not be applied to most lawful relationships. The Aristo - Galileon proposition would be as follows :-

(i)	C therefore Ef	C = cause
	or E because C	Ef = effect

"if" however, to make the above proposition into a lawful proposition, needs to be added thus :

(ii) if C then Ef

In order to satisfy features such as conditionalness, constancy, uniqueness, existential succession etc.; all important to any causal principle, proposition (ii) needs to be altered further, thus :

(iii) if C then (and only then) Ef always

Examination of proposition (iii) quickly suggests some form of regular association. The most fervent advocate of causality as some form of regular association was Hume, who rejected totally the ontological nature of the causal principle. The Humean position is dominated by the conjunction of two events blurring any real distinction between a genetic or productive link between cause and effect, and a correlation or concomitance. In other words, the Humean version of causality emphasizes relational as opposed to a real connection between the events of cause and effect. So a further proposition avoiding the Humean version of causality would be as follows:

(iv) if C happens then (and only then) Ef is always produced by it .

Proposition (iv) shows that causation is more than a category of relationship, but an actual process of production of one event by another.

Hume was not the only authority in the seventeenth and early eighteenth century of consequence concerned with the analysis of the causal principle, both Locke and Descartes viewed the principle in a very deterministic way. To them, a cause is that which produces a simple or complex idea, while an effect is that which is produced by such an idea or ideas. However, determinism is not only a matter of causation, it has other meanings, such as "becoming" or a "process", both which admittedly could be considered as part of a causal situation, but are not unique to it.

Therefore, summarising the historical development it can be seen that by the end of the seventeenth and early eighteenth centuries, a polarity had developed concerning the conception of the causal principle. At one end of the spectrum, the so called classical approach of Galileo and Newton, reflecting much of the thinking on causality by Aristotle, who saw the causal principle in very specific genetic or productive terms. At the other, end there were those like Hume who reduced the causal principle to mere external conjunction or succession of events, and provided the debate on causality with the opposite of causalism namely, acausalism. The position of Locke and Descartes on causality marks the end of this period, and is a reinforcement of the classical position, but viewed by these philosophers in the strict context of determinism; a context not confined however to the causal principle.

2.2 The Development of the Modern Conception of the Causal Principle

There appeared to be three main issues surrounding the development of the modern conception of causality, these are as follows :-

2.2.1 Issues related to a rationalistic approach to causality.

2.2.2 Issues concerned with the eclectic, functional and deterministic approaches to the semi-causal (or middle of the road) position on causality.

2.2.3 Issues concerned with empirical and indeterministic approaches to the causal position.

Each of the above will be discussed briefly.

2.2.1 Issues concerned with a rationalistic approach to causality

Of all the most important issues surrounding the nature of the causal principle, the one related to the a priori position vis-a-vis causality has generated most debate. The issue is simply, whether causality is an a priori to empirical knowledge. As far as Hume is concerned and therefore the acausal position, causality is not an a priori to such knowledge. For the classicists like Newton and Galileo, it is seen very much as an a priori, with the emphasis on the necessary connection between things.

During Hume's time, a striking attack was launched by him on this issue of a priorism. It was however Kant who rallied to the defence of the classicist position on causality, while at the same time he skilfully took a careful and balanced view of the Humean position. In so doing, Kant was able to conceive that parts of empirical knowledge became known to us via a priori forms e.g. space and time. Experience is often gained in an ordered situation as regards time and space, and when one is trying to trace why one event follows another, or that an object moves in the same direction under the same conditions. The a priori ordered context is a feature, and is very pertinent to any causal analysis and ultimately to a conception of the causal principle.

Liebnitz's position on the causal principle emphasizes it as a necessity of thought; and his so-called Denknotwendigkeit is really an example of an a priori regulative principle. This regulative principle, has been interpreted by Piaget (1972) as a useful basis to children's appreciation of causality as it gives a pre-supposition rather than a result of some enquiry. Anyone who assumes the Liebnitzian position vis-a-vis causality, has to accept the supposition of a priorism in the form of sufficient reason. In summary then, the rationalistic approach to causality is one that is based on a priorism and although there are various shades to its expression e.g. from Newton to Kant to Liebnitz, such an position entails the understanding of everything. In the words of Helmholtz the causal principle

> "could never be refuted by any possible experience .....
> ... It is nothing but the demand of understanding everything"
> in Bunge (1959) p. 28.

2.2.2 Issues concerned with eclectic, functional and deterministic approaches to the semi-causal position on causality

The semi-causal or hemiaitic position on causality, is concerned with several crucial issues related to eclecticism, functionality between cause and effect and finally neo-determinism. Eclectic theory recognises the validity of causality, but only in certain areas e.g. macrophysics of lawful production as in statistical or teleological cases. The main issue it appears, is whether a particular effect is produced by a cause or several causes, and if any links between these determinants can be established. Eclectic theory seems to recognise, that while several determinants may be at play in causation, they may concur in one and the same process. This is termed nomic pluralism and Reichenbach [in Bunge (1959) p. 28] elaborates on this phenomenon, in which a dualism of causality and probability are seen as independent principles intervening in the behaviour of all phenomena. This subject of nomic pluralism has been explored further in this study, in the way children may recognise that causes can be related to other determinants that seem to produce an overall effect. The process of probability is also taken up in this study, and both plurality and probability will be discussed in later chapters, especially chapters 8 and 9.

A second issue related to the semi-causal position on causality concerns its interactive or interdependent nature. To advocates of the functional or interactive nature of causality, such as Schelling, Pierce, etc., the causal principle can be replaced by the notion of functional dependence. In other words, there is a functionality between cause and effect, or causes and effect etc. Such a position leaves no room for chance to account for a particular effect and secondly, it fails to consider the decisive nature of a genetic (or productive) connection, and the uniqueness of a causal situation . A third issue concerned with the semi-causalist position, is the interpretation of the deterministic view in the context of causality. It appears that in examining this issue, it is necessary to mention firstly, the extreme position taken by authors such as Jordan (1944), Rey (1923) who assert the unconditionality of causality. Such an assertion is based on a fatalistic determinist philosophy. At the other extreme, is the rigid mechanistic trend in interpreting a causal sequence. Both are now unacceptable interpretations of a modern conception of causality. The former negates the existence of a lawful connection, while the latter over-emphasizes mechanicism with special reference to the limited control of causality, and which is applicable to processes other than causation.

Having mentioned the extreme positions concerned with determinism vis-a-vis causality, it is essential to examine the so called neo-deterministic view, or as Bunge calls it General Determinism. The issue here is to what extent is causality one of several interrelated categories which result in real effects? The neo-determinist view is a position of scientists who accept the replacement of the causal principle, by a broader principle of deterministic or lawful production.

In summary, it can be said therefore, that the semi-causal position vis-a-vis the nature of the causal principle, embraces three major issues. The issue that nomic pluralism is one way of establishing the nature and validity of causality in some domains and not others. In other words an issue of eclectism. Secondly, that functionality could be a feature between cause and effect, and therefore rules out on one hand the element of chance, and on the other the substantive and unique nature of causality. Finally, semi-causal approaches to the causal principle are the concern of deterministic processes. It appears, that the issue of neo-determinism with its acceptance of a replacement of the causal principle by a broader conception of lawfulness, brings the semi-causalist position very close to the more modern conception of the causal principle.

All three issues have relevance for a study of causal thinking in children, the fact that children may be able to detect several causes for an effect <u>is</u> a type of nomic pluralism. That a child's appreciation of multiple causes and for that matter multiple effects may well beg the question are they functionally dependent? Finally, as to the lawfulness and alternative explanations of causal and non-causal processes, the neo-deterministic view may prevail in the way children perceive and subsequently explain the world!

2.2.3 Issues concerned with empirical and indeterministic approaches to the acausal position

As has been mentioned earlier, Hume took a very reductionist view of the causal principle and is considered among others, of his time to be the original and the strongest advocate of the empirical opposition to causalism. The empiricist position is quite clearly one that reduces causation to external conjunction, or a succession of events, or rather to a concomitance of experiences. It strongly emphasizes the contingency of qualities of phenomena, while granting lawfulness to them. To empiricists, the nature of causation is "an episode in the history of ideas", an out-dated fetish, gradually being replaced by functional laws. *Mach (1872) and *Pearson (1911) both assert, that the causal principle is now superseded by empirically derived statistical correlations. Reichenbach (1951) even sees its replacement by laws of probability and to quote Russell (1917) :

> "the law of causality .... like much that passes muster among philosophers, is a relic of a bygone age surviving, like the monarchy, only because it is erroneously supposed to do no harm." (p. 171).

As to the indeterminist doctrine, this denies every lawful link among events and qualities and moreover denies the existence of causal bonds and as it does not seem to be defended by anybody, will be left as such by the present writer! Returning to the empirical viewpoint, the main issue is that the causal principle is <u>no longer</u> a valid or an explanatory mechanism. While historically it has contributed much of value in explaining many scientific phenomena; to the empiricist position especially that of Russell, there are no <u>a priori</u> categories involved.

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* in Bunge (1959) p. 29.

The laws of causality are therefore false as a system. It involves a set or several sets of determinants often of a different kind. A less severe critic is Meyerson (1964), who views causality in terms of identity and which must be seen in terms of a temporal dimension:

> "Thus the principle of causality is none other than the principle of identity applied to the existence of objects in time." (p. 43)

In other words, causality is the change of identity of an object or process over a period of time. However, Meyerson argues further, that the causal principle is profoundly different from that of lawfulness, as the search for a law is included in that of the cause. The cause concept is a double entity, which includes the world of reason and the world of the will. What prevails in science, is the derivation of the causal principle from identity, this Meyerson would call scientific causality. So for Meyerson, the issue is one of identity when it comes to interpreting the causal principle, and which he sees has a most important use in trying to understand and explain scientific phenomena.

It seems that there are several different views when one examines the causal principle. So far then, the empiricist views are either totally negative to the existence of the principle e.g. - Russell or reduce it to association and contingency dimensions e.g. Hume, or see it in terms of identity as described by Meyerson. To conclude this section, a brief analysis of the main trends concerned with the causal principle will be made leading up to the modern conception of causality, and its place in present day scientific thought.

The "middle of the roaders' like Bunge see the causal principle as having limited applicability, in company with him are authors such as

Medawar (1969), Braithwaite (1968) who seem to be in broad agreement with this central position. Wartoffsky (1962) describes causality as a series of alternative concepts, some of which the author has used in this investigation. Other writers like Nagel (1961), emphasizes the relational and lawfulness of the causal principle, while again Medawar (1969), seems to appreciate the existence of events, presumably accepting the notions of cause and effect but at the same time emphasizing the difference between new events. Braithwaite's (1968) classic work on explanation in science, emphasizes the regularity of events in causation with special reference to sequence, simultaneity and precedence.

Bohm (1957) is perhaps the most modern advocate of the classical position on causality, and sees it as a principle of being. He states:

> "The causal laws that a thing satisfies constitutes a fundamental and inseparable aspect of its mode of being." p. 14 - 15.

Harre [(1964, 1972)] examines very closely the two main metaphysical theories of causality namely the Generative and the Successionist Theories, and states that both theories differ in the way they treat the relation between cause and its effect. Generative theory stresses the power a cause/s has to generate an effect while the successionst theory looks in vain for another cause to a particular ~~effect~~s. Suffice to say, that science follows the generative view, and it may be a suitable place here to add, that the modern conception of causality is that, causes always act against a more or less permanent background of conditions. In science one should look for possible causes rather than particular ones.

Summarising the empirical issues related to the acausal position, and further the more recent ones concerned with current usage of the causal principle, it seems for the 'out and out' empiricist such as Russell, the causal principle is obselete and has been for some time. So the issue is one of its historical value.

A less extreme and more recent viewpoint is that taken by Meyerson who interprets causality as an identity to which changes occur over time, and which is different from the principle of lawfulness. The views of other recent philosophers of science such as Medawar, Nagel, Bunge, suggest a more cautious role for the causal principle in Scientific explanation, one which can operate alongside stable conditions.

In seeking explanations of causal situations in science the use of the causal principle should emphasize the investigation of several, rather than one particular cause to an effect or effects.

Seen in the context of this investigation of children's causal thinking, the author has borne in mind as a basis for the research questions probed and some of the instrumentation that was constructed, the cautious note referred to in the last paragraph.

2.3 A consideration of selected Aspects and Alternative Interpretations of the Causal Principle with special reference to the present investigation

The discussion so far has attempted to unravel some of the main issues concerned with the causal principle and provides a background to the discussion of causality and its historical development. The nature of causality taken for this investigation is the one formulated by the generative theorists and is as follows: Causes always act against a more or less permanent background of conditions, and that in science one should seek for possible causes rather than particular ones. However when exploring causal appreciation by children more specific guidelines are called for. Both Piaget [(1930, 1972)] and Wartoffsky (1962) have provided interesting observations of causality in which alternative interpretations of the notion are put forward. From pilot studies carried out by the author on children using Piagetian notions of causality and the alternative interpretations of Wartoffsky, a more flexible framework of causality was developed. The Piagetian components of this framework will be discussed in the next chapter, but the analysis of Wartoffsky will receive some discussion now, as it relates to the more philosophical and scientific interpretations of causality. Wartoffsky examines causality as follows:

(a) Events of cause and effect.

(b) Plurality of causes - probabilistic and hierarchical contingencies.

(c) Invariant Association of one thing with another.

(d) Causal ground; necessary condition, sufficient condition, necessary and sufficient condition.

(e) Contingent and necessary causal connection.

(f) Causality as a relation of functional dependency.

(g) Retro-active causality.

(h) Causal relation as action by <u>contact</u>, at a <u>distance</u>, and <u>sympathetic action</u>.

(a) <u>The events of cause and effect</u>

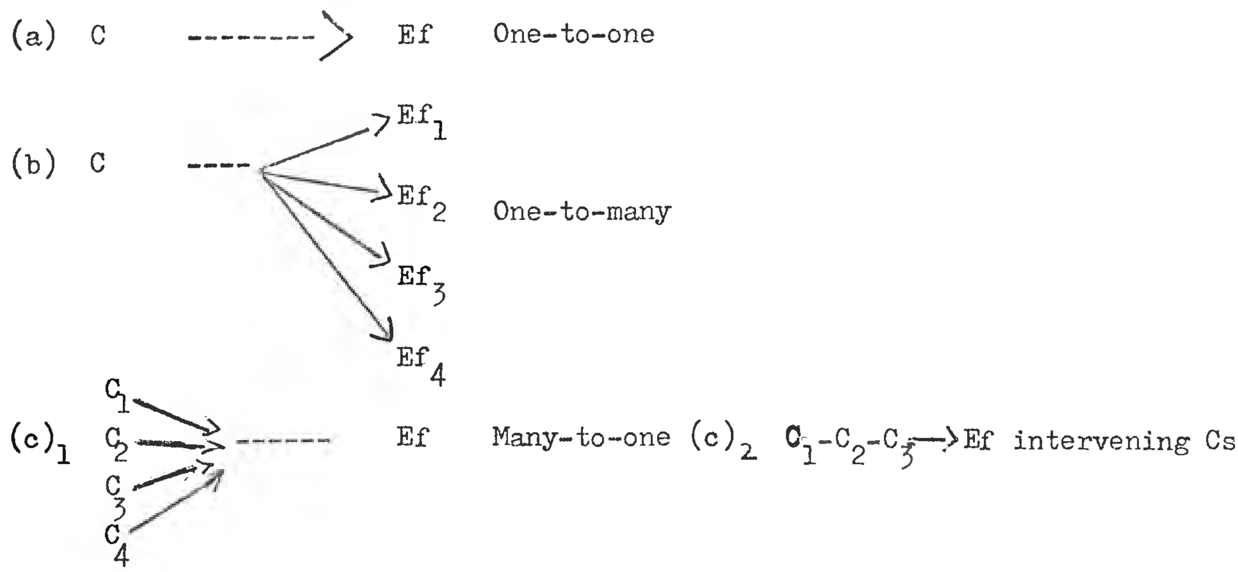
Many of the past developments in science have been concerned with knowledge about the causes of certain phenomena. This knowledge was required, in order to further understanding of events or effects. However it was pointed out earlier in this chapter, authorities like Russell see the search for causes as not only unnecessary, but harmful to understanding scientific progress and the outcome generally for scientific knowledge. However, not only do we use the notion of cause and effect to explain everyday situations, but it is also still used in science too. Again in schools, children and teachers often find themselves trying to explain phenomena by referring to their causal origins, although such pursuits are sometimes masked by curricular objectives directed towards "finding out relationships" rather than specifically mentioning causal origins. The words cause and effect are often used in a loose manner and it might be as Wartoffsky points out that the more general use of the causal principle fails to give more accurate explanation of specific causal situations. Therefore, there is a need to search for more precise interpretations of causality so that causal explanations will be more meaningful and helpful to our understanding of science.

(b) Plurality of Causes

In analysing causality, a number of conditions may be considered these are the "one-to-one" "one-to-many" and "many-to-one" (see Figure No. 1a - c). In Figure No 1 (b) and $(c)_1$ $(c)_2$ we consider the conditions as pluralistic concerning either causes or effects. In all three conditions there are the elements or relationship, sequence and probability.

Furthermore the plurality is also about relation of "wholes" and "parts" and this too, must be taken into account when analysing a causal problem. For example the movement of a car is a total effect, brought about by several causes even though the various causes may have an hierarchical order e.g. petrol, gear, engine, electricity etc.

Figure No.1 showing possible conditions that could exist between cause/s and effect/s



Key: C : cause

Ef : effect

Cs : causes

When children perceive causal plurality, it is likely that some children might have a further appreciation as to possible inter-relationships between the various causes i.e. C_1 C_2 C_3 C_4 etc. see Figure 1 (c). Whether indeed there <u>is</u> some hierarchy in the way C_1 to C_4 may be producing an effect, is another question, the point at issue here can children appreciate the multiple nature of some causal situations? This in turn now brings in the element of probability, in a very skilful explanation of probability Braithwaite refers to two main "senses" in which probability can be viewed; (a) In the sense that probability can be seen within a scientific hypothesis and referred to by *Carnap (1945) as <u>relative frequency</u> by *Kneale (1949) as <u>chance</u> and by Russell (1948) as <u>mathematical probability</u> and (b) In the sense of "reasonableness" referred

* See Braithwaite (1968) p. 120.

to by Carnap as confirmation, by Kneale as acceptability and to Russell as credibility. In this investigation, the element of probability is envisaged mostly in terms of Braithwaite's logical or scientific interpretation, as children are asked to express what is the most likely cause from a number, which they themselves might give and reasons for their selection. In other words, a logical explanation of why a particular cause or set of causes is chosen from the possible causal sources. The questions are put in such a way that the choice if made, produces an appreciation of the likelihood or reasonableness of a particular causal system. This means that the epistemological component of probability is included but to a lesser extent, lesser, because of the immediate impact of the question probing logicality, giving the child no real opportunity to respond along purely epistemological lines. This was purposely engineered by the author in order (a) to keep within the narrow limits of a logical as opposed to an epistemological view of causality; (b) because this study attempts to probe what, if any relationship exists between children's causal and other abilities especially those of a logical disposition e.g. problem solving, their conservation of volume etc..

(c) The invariant association of one thing with another

Such a view of cause arises in "whenever" instances i.e. "whenever the rain falls we get wet". Here invariance is claimed to hold between something which happens first, and is followed by a consequence, that means, there is temporal separation or some sequence between what is taken to be a cause and what is taken to be the effect.

Wartoffsky distinguishes between invariance sequence i.e. a relation between something which embraces an earlier and some later consequence, and invariant coincidence, in which two events are simultaneously coincident.

However in both cases the kind of events about whether such invariance is the feature, is the recurrent nature involving not one but a class of events. Recurrent events are related as they happen time after time, but equally important the events recur in the same relation in each instance.

Invariance therefore in this context, is seen within a lawful statement, in which an invariant association is supposed to hold. The invariant association views causality to be a matter of lawfulness and also a matter of predictability. In investigating this notion of causality with children aged nine years plus, the principal aim was to see how far they were able to detect sequence in a "lawful" context.

(d) Causal Ground: necessary condition, sufficient condition, and necessary and sufficient condition

Another interpretation of cause is seen as a source, ground or condition which gives rise to some consequence.

This type of causal situation also known as genetic cause is one in which consequence occurs through a series of intervening events (or causes). Associated with this conception of cause, is the generative origin, a beginning from which a late effect may be said to derive. Wartoffsky speaks of a cause "bringing into existence". This is an interpretation of causality in which every causal instance brings something else into existence through some activity in time. Causal ground can be seen as a complex in itself e.g. complex states of matter giving rise to some upheaval e.g. volcanic eruption etc.; here the underlying cause is one of simultaneity providing the existence of sources for certain effects. Causal ground can be seen in the contexts of necessity and sufficiency when referring to antecedents and consequents, i.e. those antecedents which were present only when the consequents were also present, where consequents are only present when antecedents are present, and finally, where consequences are never present without the antecedents.

However, such an interpretation of causality is very deterministic and gives no place for "chance" or spontaneous events. In other words, this view of causality says that all relations among phenomena in the universe are such that everything is a necessary and sufficient condition of everything else; causa acquat effectum i.e. cause is equal to an effect. But it is more than a matter of equivalance, it becomes a matter of identity already referred to earlier in this chapter, and a matter which Meyerson has addressed himself most adequately in his work entitled "Identity and Reality." These conceptions of causality were also explored in this study, to find out to what extent children supposedly exhibiting concrete modes of thinking at age nine plus are able to begin appreciating such causal subtleties or not?

(e) Contingent and Necessary Causal Connection

A causal relation is said to be contingent when it could be otherwise than it is. In the example where "a child missed his science lesson because he was ill", it is conceivable that (a) he could have attended the class even if he was ill; (b) or he may not have been ill at all.

In (a) the causal relation is seen as contingent while in (b) the cause itself is seen as contingent. If the child missed the science class as he was many thousands of miles away, logically speaking he would be able to go, but empirically speaking he would not have got there on time. If death had intervened, getting to the class from a logical and empirical point of view is an impossibility. In other words we have a case of necessary causation in an empirical instance.

In analysing such a view of cause, notions of determinism are bound to be considered. In the case of a car accident involving two causal chains i.e. either due to mechanical causality or human causality of intention, the accident could be from either chain, an accidental event.

Therefore, a distinction can be made between what might be called "fatalistic determinism" and "contingent determinism". In one way every causal situation can be seen in such terms, in which contingency is only the appearance of things underneath which is the "real" deterministic, fatalistic nature of the situation.

Now when viewing this type of causal notion, and discussing its relationship to scientific laws, one is faced with the dilemma that laws are stated in precise form for universal applicability, while our knowledge of necessary and sufficient tell us they are unwarranted empirically. This it seems, has engaged scientists and philosophers separating conditional statements of laws from unconditional postulates of causality. Contingent and necessary cause was also explored in this investigation, to see if and how children appreciated such causal notions, and to see if they were able to detect or begin to detect an overlying contingency beneath a bed rock of determinism.

(f) Causality as a relation of functional dependency

A functional dependency relation is one in which the values of two variables are said to be related in some law-like formulation. This view of causality tends to reduce the case for causality in terms of causal ground, necessary condition, sufficient condition, necessary and sufficient condition as well as contingent and necessary causal connection. This is because they speak of originative causal grounds, or necessity and mathematical laws formulated in this way, to answer these conditions, and make all ontological claims about "real" and necessary. This means, we cannot apply such a conception of causality as we do not know enough about the other variables involved in the relations. For instance applying causality as a relation of functional dependency to investigating an effect when temperature increase is related to pressure increase, is more possible, as we know what we are measuring and manipulating. Causality is scientifically formulable when a causal situation is portrayed in a formulated manner e.g.

$$F = m\ (d^2\ x\ /\ dt^2)$$

However, one could agree with Russell when he states that physicists make do with differential equations and therefore they bypass or ignore animistic, anthropomorphic views of cause. Does this mean however, that the physicists do not consider any metaphysical interpretation of cause?

The use of cause in this particular context was not followed up as such in this investigation, although the relational element referred to above was explored in several tests.

(g) Retro-active Causality

Another conception of causality, is one which introduces the feedback element into it. There are many instances in science of such conditions, but little if any investigation, has been carried out on childrens' conception of this type of causality. An example of such retro-active causality would be as follows:-

> "the more the girl laughed the louder her voice became, the louder her voice became the more she laughed".

Her laugh is causing the voice to get louder and voice loudness presumably, now causes more laughing.

In a way this can be interpreted as a lawful relation but one in which there is a relation of invariant or statistically ordered succession. A succession where antecedents and consequents are temporarily separated, but in which a consequence becomes an antecedent, for that same class of events, which was its antecedent.

Now feedback systems are usually systems with a preferred state of operation, or have some end which all the parts of the system subserve. However, such an explanation usually means the awareness of a system to this preferred state or "end". In physical systems like central heating, the question of "ends in view" is lessened by self-regulating mechanisms, as so-called law ordered physical systems, in which retroactive causality is so structured that there are loops which transmit cause and effect. However, such a system requires energy as an input and one could argue this initiates the whole causal chain. In other words, energy source is <u>the</u> initial cause. This rather difficult conception of cause for children to appreciate is nevertheless a notion which appears in school science curricula e.g. rain cycle, central heating system etc. and for this reason was investigated in this study.

(h) <u>Causal Relation as action by contact, action at a distance and sympathetic action</u>

Perhaps one of the most common interpretations of the causal principle is that of action. Wartoffsky's explanation of causal relation in terms of action finds three dimensions, action by contact, action at a distance and sympathetic action. These forms of causality are interesting and relevant ones to consider, when studying children's conception of cause. This is because, they are for the most part appreciated by them during some time in their lives. These three conceptions of causality may be explained briefly.

When a stone strikes a glass and breaks it, we have an instance of action by contact. The effect is a direct result of an impact which contains the elements, contact and force.

Action at a distance, may be exemplified by gravitational force. However, in classical mechanics, Newton's space is not a medium, such a force acts instantaneously rather than by causal transmission through time. However, as Wartoffsky points out, the fact that we use models in science in which we pull strings etc. underlies our unease about causality, action and distance.

Even more primitive interpretations of this notion of cause, is met when there is talk of dreams and spirit which are given causal properties and are supposed to produce effects at a distance. These interpretations extend also to magical explanations, and in scoring childrens' responses to questions of physical causality, Piaget (1930) included such conceptions in some of his seventeen ways children appreciate causality. Nass (1956) who explored this area further preferred to call such responses, Non-naturalistic.

Causality as a sympathetic action is seen when a wish is expressed. The realisation of which is effected by the force of the wish, without any mediation. This type of causal notion has more than a "magical" ring about it. It is perhaps here above all, that Russell's view of replacing causal notions by differential equations becomes strongest. Action models of causality are supposed to be wanting, because they are opaque or redundant. They are opaque in that we are unable to solve the origin of such a relationship; redundant in that causality is explained with a model. However, causal relations are seen by both children and adults in terms of action models, real connections between things, production of effects by causes, conceptions of cause in terms of "effort" etc.

Causality is often seen as happening spontaneously, out of nothing. While such notions of causality conflict with actual explanations of cause they nonetheless are the way children and adults view the world, and are therefore essential to explore from the standpoint of how scientific explanation through causality develops; indeed any explanation of causality be it physical, social or psychological.

CHAPTER 3

THEORETICAL APPROACHES TO THE PSYCHOLOGICAL STUDY OF CAUSALITY

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INTRODUCTION

In the last chapter the philosophical and scientific interpretations of the causal principle were examined. This was done to provide an important background to a consideration of the principle, and to give the psychological perspective with which this thesis is concerned, a more fundamental basis.

This chapter and the two that follow, will review the pertinent psychological literature concerned with causality, and more specifically physical causality. Through reviewing the literature, an attempt will be made to bring into the open some of the theoretical and methodological questions any psychological study concerned with causality is likely to meet, and which this investigation has explored and tried to answer.

Two areas will be discussed in this chapter.

3.1 "Philosophico - Psychological Bridges" and the investigation of the Causal Principle.

3.2 The Genetic - epistemological view of causality - the Theory of Jean Piaget.

3.1 "Philosophico - Psychological Bridges" and the Investigation of the Causal Principle

Causal relations are among the larger category of functional relations, which include spatial and temporal processes, and which are invariably inter-linked sometimes in a complex manner. One has only to read the works of Piaget (1942), Janet (1935)*, Bruner et al (1966), to see the emphasis that these psychologists put on the importance of studying relational thinking. However, Michotte (1963) pointed out that only problems concerning the epistemological nature and origin of functional relations have received most attention. However, this is only partly true, for since Michotte's work on the perception of causality, Kelley (1973) and Siegler (1975) have investigated the mechanics whereby children and adults appreciate causal plurality. More of this recent work will be mentioned later in the next chapter. However, at this point, let us consider the link or bridge that exists between the philosophical and psychological interpretations of causality, for it is the opinion of the author, that each interpretation is crucial to the understanding of the other, and in the final analysis to causality itself. No psychological study of causality can ignore the philosophical and scientific debate, that took place in the long history of the causal principle, and its importance or otherwise to the furtherance of human understanding. Although in the 20th century, the causal principle has been perhaps put into its "proper context", i.e. one of many scientific principles useful but not always necessary to explain scientific phenomena, it nonetheless figures prominently in the way children and adults explain the world around them. For this reason alone, a study of an appreciation of causality is justified.

The origin of the idea of causality, has always held an important place in philosophy, science and in psychology too. The problems concerning causality which philosophers like Hume, Kant and Malebranche probed, were mainly epistemological ones. They were concerned to discover what will justify the characteristics of necessity and universality, by

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* In Michotte (1963) p. 4 - 5.

advocating that necessity and universality could not be derived directly from ones own experience.

Hume (1748) however, went further when he asserted that in perceptual experience, we have no direct impression of the influence exerted by one physical event or another. Causality, according to Hume is a process of regularity in the succession of events, and is based on anticipation and expectation, i.e. one event follows another.

This interpretation found favour with the associationist psychologists, and the present day behaviourists, who are fervent advocates of an analytical and objective stance in explaining human behaviour.

The interesting theory of the eighteenth century philosopher Biran, provides another interpretation of causality, in which internal experience plays a vital role in the experience of our own causality. For Biran this experience constituted the primary fact, providing the foundation for all psychology and philosophy. It is a theory from which *Ach (1910), Michotte and Prüm (1910) have derived useful guidelines for their work on causality. Therefore, one of the bridges we can talk of here is that "internal" experience and "external" experience, as far as causality is concerned are on the same footing.

The theory of Biran was incorporated into part of contemporary psychological thought by Piaget's work on the origins of causality in children. Piaget (1930) has this to say about Biran.

> "The fact the idea of force owes its existence to inner experience seems to be beyond dispute. To Maine de Biran belongs the merit for having stressed this origin". (p. 126).

Although Piaget's Theory of how children develop the appreciation of causality will be discussed later, it might be worth mentioning here that

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* In Michotte (1963) p. 11.

for Piaget, the world of the child is undifferentiated at first. It does not contain things and a self as separate entities as Biran states. There is little differentiation between the internal and external self.

> "For everything happens as though the child began by attributing forces to all outside bodies, and as though he only ended by finding in himself the "I" that was the cause of his own force". [Piaget (1930) p. 128]

It is in the course of development that a separation is made in the processes of accommodation and assimilation.

> "...... force becomes gradually withdrawn from external objects and confined within the ego". [Piaget (1930) p. 132]

and again Piaget (1955)

> "Assimilation and accommodation are dissociated to form increasingly complex systems ... To the extent that this occurs, the causal nucleus - personal activity - is broken into a series of centers by the progressive objectification of causality". (p. 316)

For Piaget, a child eventually develops from a state in which it seems to him there are connections between certain events, and in which there is an awareness of efficacy i.e. with feeling a bond between the desire and the result obtained.

This view of causality, eventually fades and is replaced by a mechanical and later a more rational conception of causality. Nevertheless, Biran's emphasis on internal experience as an essential part in interpreting causality, was a source of inspiration in formulating Piaget's own view on causality.

So far we have mentioned behaviourist and genetic - epistemological approaches to the explanation of causality. Before leaving this section mention will be made of the Gestalt view as it too, has a valid contribution to make to the debate.

Köhler (1929) sees the use of insight as a natural way of explaining causal phenomena, and Koffka (1935) mentions, it is conceivable that one should have a specific impression of causality. Duncker (1935) emphasizes that where there are causal relations, the events, effect and cause, are not always so detached or separate from each other as Hume had indicated. To Duncker it seems there is a degree of "Einsichtlichkeit" or the quality of being accessible to insight. This means that the link (if one can use this word) between cause and effect, has spatial coincidence, in which a position of a cause is marked by the position of the effect.

The link may also have temporal coincidence, of two events unrelated, happening simultaneously. Furthermore, the link may be one of correspondence, regarding form and matter, e.g. the marks made by the paws of an animal have the same shape as the object which imprints them.

In these cases the Gestalt notion of intuition, can be seen to be one way of interpreting spatial, temporal and correspondence causality. From what Duncker writes, it as essential that the cause event consists of an "encounter" e.g. the coming on of a light, coinciding with the arm pressing, a switch. The action of arm press and the switch being called "Weltinien" or "World lines", which intersect temporally and spatially. Whereas the Gestalt view of treating causality might be considered by scientists as inadequate; from a developmental psychological point of view it makes much sense.

From the author's experience in this investigation many children have explained causal situations in terms of spatial, or temporal coincidence or, correspondence - like dimensions, however what part insight played in the explanations is open to debate? Metzger's (1941) position which is near to that of Duncker, is convinced that one can have an immediate impression of causality in one's external experience. This stresses the importance of the structural principle of priority, in space and time for producing this impression. Once again, the point which needs to be made here is that Duncker, Metzger, Michotte and others from the Gestalt school are probably on suspect ground at a scientific and to some extent philosophical level. In the first place, scientifically suspect due to the lack of objectivity shown in such a treatment of causality, and in the second place philosophically suspect, insomuch that there is only emphasis given on internal organisation, a feature so characteristic of Gestalt psychology. Nevertheless, these views of the Gestalt school widen the total picture of causality, and provides a valuable view into the way children appreciate causal relations, and without which, developmental psychology would be the poorer.

So it seems that associationist, behaviourist, genetic epistemological and Gestalt views on physical causality, each provide interesting and perhaps in some cases, valid approaches to the study of causality. On the one hand, the associationist and behaviourist views dovetailing neatly and providing an empirical analysis of causality. On the other hand, the Gestalt pre-occupation with internal organisation, insight etc. parallels the rationalistic school of causal analysis. The middle ground position might be that of the genetic epistemologists, linking in with the more modern scientific conception of causality, as put forward by Medawar and Bunge etc. but related to some extent to rationalistic views, Piaget (1972).

Therefore it would appear that we have at least three "bridges" linking philosophical and psychological interpretations of causality, these being :-

(a) the Associationist - Empirical

(b) the Gestalt - Rationalistic

and (c) The Genetic - Modern Scientific/Rationalistic

While all three "bridges" will be referred to in various ways in this investigation the Genetic - Modern Scientific Conception of causality will receive the greatest emphasis; this is because :-

(a) The Genetic-epistemological approach to Causality is the only psychological approach of any consequence, that has attempted to analyse children's appreciation of causality.

(b) The Modern Scientific and somewhat indeterminate view of causality, fits the present mood of science education, i.e. favouring a more open and exploratory basis to investigating relationships, be they causal or otherwise, and to which the Piagetian Genetic approach lends itself particularly well.

Finally

(c) A genetic epistemological approach to children's development provides an essential basis, with much value and practical significance for improving classroom learning.

It is to the genetic-epistemological approach that we now turn.

3.2 The genetic-epistemological view of causality - the Theory of Jean Piaget

Piaget's work on causality falls into three main periods. In the first or early period, he dealt specifically with the child's intellectual attitudes to causality and coupled with this, the child's notion of the world. This forms an early period in Piaget's career, in which the strong influences of his training as a mathematician and epistemologist can be detected. Therefore, it is only natural to find a strong philosophical thread running through much of his writing on causality. The Child's Conception of the World (1929) and The Child's Conception of Physical Causality (1930), provides the expression of Piaget's ideas on reality and causality respectively. A second or middle period in Piaget's interest in the notion of causality, is marked by a study of the Child's construction of reality. In his book The Child's Construction of Reality (1955)* Piaget devotes some space to the genesis of causality through development of the object concept, but seen against a background of the child's spatial and temporal processes. The early part of the third period is marked by a continuation of Piaget's experiments on causality in the 1920's and 1930's. These experiments included investigating childrens' causal explanations of the change in the centre of gravity; Piaget and Maier (1965), reciprocal motion; Piaget and Papert (1965), spiral and rotational movement; Piaget and Monoud (1965a). He also examined the notion of force as a causal agency Piaget (1972), Piaget et al (1973a and 1973b).

However, the third period is also marked by Piaget's extensive work into causal thinking and memory processes, Memory and Intelligence written by Piaget and Inhelder (1973). Furthermore, his observations on the relationship between Causal and Operational Thinking; Understanding Causality written by Piaget (1974) in collaboration with de Garcia also comes into this period. In the discussion of this period, to follow later in this chapter, only the later work on memory and operational thinking will receive detailed attention because of its immediate concern to the present study.

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* Originally written by Piaget in 1937.

So it can be seen, that Piaget, and later with his Genevan collaborators have, over a span of 47 years attempted to provide cognitive development with firstly, an essential genetic epistemological and experimental basis to the study of causality (as well as reality). Secondly, attempted to trace the relationship between remembering causal phenomena and their understanding, and finally, to tease out some of the intricate relationships that exist between causal and operational thinking. In the discussion that follows, reference will be made to developments in each of these periods, although some aspects will receive more attention than others, where they have particular relevance to this study.

3.2.1 The Early Period

Piaget (1930) has put forward three main periods in the development of a child's appreciation of causality. During the first period, children explain causal phenomena through psychological, phenomenistic, finalistic and magical interpretations.

In the second period, children give explanations that are artificialistic, aministic, dynamic as well as magical.

Finally, in the third period the preceding types of causal responses disappear in a fairly progressive manner to give rise to more rational explanations such as mechanical, and logical deductive ways of interpreting cause. Table No. 1, sets out these three Periods and within each, the main type of causal explanation. Periods 1 and 2 Piaget (1930) calls pre-causality that :-

Table No.1* Showing Details of the Piagetian Development of Causal Thinking in Children

Approx. Ages	Macro Period	Period	Type of Causal Explanation	Examples	Evolutionary Processes 1	2	3
3-8 yrs	Pre causality	1	i Motivation	"God or men send us dreams."	Desubjectification	Formation of Series in time	Progressive Reversibility
			ii Finalism	"The river flows so as to go into the lake."			
			iii Phenomenistic	"A pebble will sink because it is white."			
			iv Participation	"Dreams are sent to us by the birds who like the wind."			
			v Magical	"The stones makes the water flowers grow."			
			vi Moral	"Clouds must move to give the night."			
5-8yrs		2	vii Artificialist	"Stones did the rolling."			
			viii Animistic	"Mountains grow, clouds are alive."			
			ix Dynamic	"The glass broke by itself."			
8-15yrs	True Causality	3	x Reaction to surrounding medium	"Clouds move themselves and then helped by the wind."			
			xi Mechanical	"The wind pushes the cloud."			
			xii Generative	"The clouds have come out of smoke."			
			xiii Substantial Identification	"The sun is a collection of clouds rolled into a ball'..			
			xiv Condensation Rarefication	"The clouds have been well packed into a ball."			
			xv Atomistic	"Stones are made up of little ones."			
			xvi Spatial	"Rise in water level due to putting in a brick."			
			xvii Logic-Deductive				

* Compiled by the author

> "by confusion of relations of a psychological or biological type in general with relations of a mechanical type". p. 267.

While Period 3 constitutes true causality and does not appear until the child is about 7 - 8 years old.

Accompanying this evolution in the appreciation of causality, Piaget identified the following processes :-

(1) desubjectification of causality,

(2) formation of a series in time,

(3) progressive reversibility of the systems of cause and effect.

(1) Desubjectification of Causality - This is a very definite process, like reality, causality is teeming with subjective elements and is typified by children being unable to distinguish between motivation and physical causality, or between muscular/manual activity and mechanical action. Piaget confirmed that children up to 7 - 8 years of age were unable, to genuinely put forward physical explanations of natural phenomena. After age 7 - 8, more positive forms of causality gradually supplant the others, so that by age 11 - 12 years the evolution is complete.

(2) Formation of a series in time - this is peculiar to causality, as any causal situation constitutes a temporal series. Piaget here, underlines the fact that the child's most primitive form of causality is the immediate and almost extra-temporal character of the relation. Piaget cites the case of "the pedals which make the wheels go around simply by influence." There does not seem to be a series between cause and effect. Progress consists of precisely establishing chains of intermediaries, such that each should be the effect of the one that precedes it; and the cause of the one that carries on after it.

(3) Progressive Reversibility of the systems of cause and effect - here a progressive establishment of a reversible series is the key feature. Of all the types of causality that come before that of mechanical causality, explanation by reaction to the surrounding medium is the one that points most clearly to the beginning of reversibility. To Piaget, this is the type that clears the way for the higher forms of causal explanation. The progress from non-reversibility to reversibility, is therefore continuous and follows along the same lines as those for reality.

The three processes described above by Piaget, comes fairly near to that of Meyerson's notion of identity discussed in Chapter 2. However Piaget prefers to use the term reversibility rather than the term identity for the later stages. This he clarified by saying that to explain is to deduce (which presumably means expressing reversibility), while deducing does not really mean to identify.

Causality, is seen as the result of a sort of bodily contact between the organism and the world, which is prior to consciousness of the self. For Piaget (1930) causality is not fixed as an a priori notion: it is flexible and a notion which is assimilated and eventually modified - later on, involving adaptation :-

> "If there are; in causality signs of a structure which eludes empirical explanation it will have to be admitted that this structure is plastic and this leads us back once more to the hypothesis of an assimilation of external objects by the organism and such that the organism in its turn accepts things outside its own peculiar nature". (p. 273).

Any discussion on the notion of causality must consider also the notion of law. According to Piaget, the idea of law embraces two complementary features - universality and necessity. Law is a constant and necessary relation. Piaget cites Meyerson's work in which he draws attention to the fact that in distinguishing legality from causality - legality is simply generality, while causality is seen as something more specific, actually furnishing a particular case for necessity. However as Piaget points out, law is inconceivable without necessity to the child. Piaget outlines three stages in the evolution of law in the child, which reflects the relationship between generality and necessity.

Stage I This lasts up to the age of 7-8 years and is characterised by moral and physical interpretations of a necessity, while generality is absent. Artificialism and animism is very much a feature of the type of explanation given here. In this stage, everything is willed, there is no evidence of chance coming into a child's conception of the causal world.

From Piaget's observations, the necessity of law is entirely moral, and physical necessity is simply the lining as it were of this moral necessity.

Stage 2 This occupies the period from 7-8 to 10-12 years, and is typified by the differentiation of moral and physical necessity, and where generality emerges. Very much a feature in this period is the appearance of the appreciation of chance. Mental structures show that the idea of uniform and physically determined causal sequences are common patterns of thinking.

Stage 3 This begins approximately at the age of 10-12 years and is characterised by generality becoming established, and physical determinism becoming accompanied by logical necessity. According to Piaget, logical necessity replaces so called moral necessity, in that the child attempts to further explain causal situations by deduction and logical justification.

In summarising his earlier thoughts on causality, Piaget (1930) describes the evolution of two parallel processes, one being logical the other ontological. Up to the age of 2-3 years, autism is representative of this logical pattern, while an ontological pattern is manifested by psychological causality, probably in the form of magic proper. Piaget views autism and magic as two different sides of one and the same phenomenon - i.e. the confusion between self and the world which destroys both logical and objective existence.

From 2-3 to 7-8 years of age, egocentricity characterises the logical point of view, while pre-causality characterises the ontological domain. In this period, participation and dynamism are particularly important, and finally from 7-8 onwards as logical thought breaks through, transduction becomes deductive and the idea of reality breaks away from all form of primitive realism, so that another parallelism grows between logic and real categories.

In this early Piagetian view of Causality, parallelism receives a final comment as to whether the content of thought fashions its logical form, or is the converse the case? It is one of the issues which some of this study has tried to get to grips with, and which the author has recently commented on in a cross cultural context, Thomas (1981). It seems that logical expression as far as causality is concerned does depend on the nature of the content, and situational variables such as probing, teaching and the role incidental learning may play in the process. This and other related issues will be discussed in Chapters 11 and 12.

3.2.2 The Mid-period

Between the early work on physical causality and the recent theoretical and experimental sophistication of the third period, in which causal thinking is examined against a backcloth of mnemonic and operational processes, Piaget devoted his time and energy in investigating the child's construction of reality. In this work, he constructed an elegant series of propositions concerned with several aspects of what he thought constituted reality. In the first place, he devoted some time to the way the "object concept" developed in children. To Piaget, the object concept is far from being innate, it is constructed little by little. This is accomplished in 6 stages, which correspond to intellectual development. By the end of these stages, a child of 16-18 months has an image of absent objects and other displacements.

The formation of the object concept was then seen by Piaget to relate to the Spatial field and the Elaboration of Groups of Displacements. The development of Spatial field, according to Piaget parallels that for object concept, where the child remains outside the space, and so space is only a property of action. By the time the child has fully developed an appreciation of space, space is seen as a property of things, the framework in which all displacements are located including the actions of the subject.

Objects and space also exist in the dimension of time, and Piaget devotes some time to the temporal field. Again Piaget, sees the formation of time as parallel to that of space, and to the concept of object. The development of the temporal field proceeds equally from the immediate characteristic of what Piaget calls "radical egocentricism", to a broader relational process embracing a coherent universe. Of particular relevance to this study, are Piaget's views expressed in this middle period on causality. It is clear, that in discussing the place of causality in the child's appreciation of reality, what has been mentioned earlier for the period, namely the development of object concepts, spatial field and the temporal field are integral parts of any study of causality. Time limits further discussion of this period except to say, that the development of object concept, spatial field and temporal field run closely parallel to that of causal thinking and its development. One could perhaps go further than Piaget and consider, that it is not only a case of parallelism but one of a complex or nexus of factors, embracing the above components of reality.

Piaget devotes a considerable section of his writing on the child's construction of reality to the genesis of causal thinking, and as this particular study is concerned with older children, only brief reference will be made to it here.

Most of the work on the genesis of causal thinking carried out by Piaget in this period relates to the sensori- motor stage of intellectual development.

It appears that for Piaget, the development from egocentrism to objective relativism is a plan of evolution, that is common not only to the appreciation of spatial, temporal and object notions, it is the process in which causal thinking develops in children.

At first, there is no causality for the child other than his own actions: The world is not a place of oausal relationships and sequences, it is a mere collection of events. At the beginning of the sensori-motor stage there are two poles of elementary causality, efficacy and phenomenalism at one end, and at the other, the universe has become a coherent whole in which effects follow causes. Piaget sees the development of causality during the sensori-motor stage in six stages. In the first three stages the child attempts to make contact between internal activity and the external environment. These stages are marked by two processes. The first, being a more primitive feeling of efficacy in which activities such as the food obtained, is perceived as an extension of the act of sucking. The other, and the polar opposite of efficacy is phenomenalism in which causality is seen in terms of an outside agency, but which may not be the actual cause. By the end of the third stage, efficacy and phenomenalism are not totally dissociated from one another.

However, by the fourth stage as soon as the schemata begin to operate in an intentional series of actions, the child is able to detect ends from means, or causes from effects. The fifth stage, emphasizes the role of tertiary circular reactions, and developing new means through experimentation, which contribute to the formation of causality leading to objectification and spatialisation of both activities.

By the sixth stage, representative causality, that is cause being an attribute of something else, owes its particular development to deduction and mental combination from practical situations.

Perhaps the most important aspect of this work of Piaget on the genesis of causal thinking for this study, is the development and ultimate dissociation of efficacy from phenomenalism. Phenomenalism in some causal situations e.g. origin of lightning etc. appears to linger well into the early concrete stage of development, a feature that was encountered by the author during the pilot studies even with 10 and 11 year old children.

3.2.2 The Third Period

(a) Causal Thinking and Memory Processes

Piaget and Inhelder's (1973) work on memory and intelligence is pertinent to the present study which examines the appreciation of causality over time and therefore implicates memory processes. One question asked by Inhelder and Piaget concerning the rememberance of causal structures, was to find out whether remembering causal structures obey the same laws as to logico-mathematical ones.

In trying to answer this question a series of experiments were designed by these workers which involved children remembering causal processes by using levers, remembering causal processes using transmitted motion and, employing memory of incomprehensible causal processes. Only the first two experiments will be discussed here as they have relevance to this study. In the experiment on levers, children from 4 years, 6 months to 12 years, 2 months were tested by being asked on separate occasions to move models. One of the models is rigid and held in parallel by a slide, the other fixed by a nail on a board but with a handle which when produced several positions of the various parts of the lever. The experiment took place over 6 months, with three testings in all, a second after a week and a third after 6 months. Children were asked to recall the mechanisms of each model by verbal description and drawing. In this experiment, the child performs the action himself, and Piaget and Inhelder claim that it is possible to determine whether he remembers no more of his action than that it was a succession of events, or whether memory is governed by a level of causal comprehension.

Unravelling the level of causal understanding and the level of mnemonic recall is a difficult task, as so much reliance was put in the contents of verbal descriptions, drawings and commentaries at the various presentations. Generally speaking, Piaget and Inhelder found that what is retained is what is understood. They describe three principal stages which are briefly is follows:

In the first stage the subject recalls a direct and overall connection between his action and their results, "you push the handle and one of the pieces of wood moves up." in other words the children remember what they have understood.

At the second stage the details of the articulation and their spatio-temporal relations are reproduced correctly in the form of drawings and descriptions, but the reason why is not understood. According to Inhelder and Piaget the subject still thinks there is a causal link between his actions and their results. This is illustrated by responses of some of the children interviewed by Piaget e.g. with the rigid handle, phrases like, "we pushed and then that one just went up". With the flexible handle, a phrase like "the other one went down like this because there was something that made it".

In the third stage the child's drawing and description alike, show that he now seeks the reason why in the interaction of the segments. It is no longer in terms of his own power to alter the spatial arrangement, as it is controlled by a screw in the middle allowing a vicarious movement. This was illustrated by phrases such as "That one (the rigid handle) was all screwed together and here (the flexible handle) is a screw in the middle".

The second series of experiments which Inhelder and Piaget carried out in this area involved transmitted motion. It was an experiment in which a ball A (red) is released by a mechanical device from the top of a slope. It then hits a wooden plug fixed to the slope which transmits the motion to a second ball B (green). This in turn hits a plasticine stopper which is removed, whereupon B, hits the second plug behind which lies a third ball C some distance from the plug.

Piaget and Inhelder point out that this experiment is of special interest in that the motion of A is transmitted to B, that of B is not transmitted to C. Again, neither experimenter or subject initiates any of the motion directly.

The child is asked to describe the model before him, then the model is removed and the child is asked for another description followed by a drawing and then a commentary on the drawing. The same procedure is adopted a week later, and again at 4-6 months. The ages of the children ranged from 4 years 6 months to 10 years.

Briefly, Piaget and Inhelder distinguish 3 levels - Level I continuing until the age of 6 in which the youngest subjects explain the action in terms of the experiment. Level II begins at the age of 6 and is characterised by the affirmation of the transmissions of the motion of A to B, but a failure to grasp that the motion of B is not transmitted to C once the plasticine is removed.

Level III characterised by the children, saying that the last ball stays put, as there is a gap between the plug and the ball C. Mnemonically, Level I is characterised by the failure or reluctance to seriate successive events in the descriptions and the drawings. Level II shows the beginnings to seriate sequence of events, but in which many subjects distort the data. Level III is characterised by a greater but not always complete mnemonic accuracy.

This recent work of the Genevan school on causality and mnemonic factors throws much light on the mechanism of childrens' causal thinking. Furthermore it introduces a useful methodological dimension into the study of causality, in that a variety of methods e.g. verbal, psychomotor etc. are used to probe the child's understanding of the notion. In the present study some regard has been paid to the use of verbal and psychomotor interpretations in studying children's causal thinking, and these results are discussed in Chapter 9 and 11. This approach to the study of childrens' causal thinking using several modes of experimental enquiry e.g. drawing, description etc. is an important facet of Piaget's approach to causality, in this third period, enriching further the value of the clinical interview. Summarising this section of the third period of Piaget's work on causality, the following can be noted:

(1) It adds an important methodological dimension to researching causal thinking over time.

(2) It tries to grapple with the process of development and the mnemonic factor by the same children at certain stages. Inhelder and Piaget raise the question of whether the child simply gives an explanation because he remembers it, or does he actually understand what he has remembered. Their interpretation, is that what is retained is what is understood. However, the findings of Inhelder and Piaget may be simplistic, for it does not necessarily follow that retention means understanding every time, as has been found in this study.

(3) This recent work of Inhelder and Piaget has tried to shed light on what differences and similarities exist between the rememberance of causal structures and logico-mathematical ones. In both cases they find that the child's memory reflects his level of understanding. Although, as they point out, similarities exist between how children understand logico-mathematical structures and their comprehension of causal ones. The essential difference however to them as far as the two types of memories are concerned, is that in remembering causal situations the child cannot ignore the time factor. In explaining a causal situation one not only describes the results but tries to trace the events that lead up to them. Whereas in remembering logical

mathematical situations, results and operation are identical as the time factor is minimal. It is here that the use of symbolic reconstructions may be useful, for such reconstructions are valuable in assessing what a child remembers and according to Piaget what he understands of the sequences he has observed, and not merely the end result or final effect.

From this research work of Piaget and Inhelder, five points need to be mentioned inasmuch as they relate to the present investigation.

(1) It seems that the development of memory from the three test occasions appears as a massive transition from accurate figurative recall to a schematic type which is subordinated to causal interpretation.

(2) Intellectual progress plays the same part in structuring the memory process as it does in the case of logico-mathematical structures.

(3) In the relationship between children's understanding and memory it is not clear as to which affects the other most. But, from the changes observed between the first 2 occasions and the last, four distinct reactions occurred:

- (a) Data are badly remembered and poorly interpreted due to memory gaps and failure to grasp relationships.
- (b) Data are badly remembered but correctly interpreted.
- (c) Data are well remembered and poorly interpreted which Inhelder and Piaget found rare in their sample.
- (d) Data are well remembered and well interpreted, children as they grow older arrive at (d) because according to the Genevans their intellect has developed in the meantime.

(4) Over an interval of several months there is a mental reinforcement of the interpretative as opposed to the figurative aspects of memory.

(5) That there is a deterioration in the number of correct drawings and an increase in the number of distortions which according to Piaget and Inhelder (1973) is not a regression but a sort of consolidation period.

Points 1, 4 and 5 will be taken up in more detail in Chapters 11 and 12 as they are closely related to what the author has found, whereas points 2 and 3 are less related to the present study as they represent findings common to most investigations on memory and children's cognitive development. This work of the Genevan school on mnemonic factors not only relates to causal structures, but to mental structures in general and is likely to inject new thinking into the part memory plays in mental development.

(b) Causal Thinking and Operational Thinking

In the latter part of Piaget's third period into his study of causality, he with R. Garcia turned to examine and trace the relationship between causal thinking and operational thinking. This work is reported in detail in "Understanding Causality" in which he collaborated with Garcia. According to Piaget, Stages in the Understanding of causality pose much more difficult problems than the study of operations in subjects. Explaining physical phenomena presumes the use of operations for the search of the causal factor or factors. This frequently means, going beyond the observable and having recourse to inferred conditions. Causal explanations, do not present the same regularity and simplicity as do logico-mathematical operations, for causal explanations depend more on the objects than on the subjects.

Piaget goes on to argue that the psychogenesis of causal explanation seems to show that such explanations bear as much on transformations of objects as transmissions and conservation, while the operations of the subject intervening in the play of inferences can be an agent to transformation as well as of conservation. This results in a convergence of operations and causality, the former stemming from the subject and the latter from the object.

Piaget further elaborates his position by examining first the primacy of operational thinking and secondly the primacy of causal thinking. In summarising the possible primacy of operational thinking, emphasis is given to so-called endogenous construction of operational instruments i.e. step-by-step processes with main attribution to objects, leading to new explanations and therefore new causal structures. However, the development of operations is closely related to the development of causality, in that it determines its course of action due to the overriding influence of concrete operational thinking.

In examining the reverse situation, i.e. possible primacy of causal over operational thinking, Piaget entertains the fact that the development of operations constitutes a reflection first internalised, and then formalised of causal notions successively imposed on the subject by reality. Before structuring objects the subject, will try to utilise and modify them, with an eye towards effects or physical modifications implying an indefinite whole of causal interactions. In other words, Piaget argues that each operational progress rises from a need for comprehension, that is initially triggered by a causality problem. Causality is seen by Piaget as interdependent with a construction of the object in space and time. With every sensori-motor causality, there is a system of schemas of intelligence and coordinations giving rise to the final form of operations.

In examining the interaction between operational and causal thinking, every level of the development of causal thinking proceeds by interacting with the development of operations. Causality proceeds from a specific action leading to a generalisation of relationships between objects, and since the operations themselves are derived from actions and from their coordinations, there is simultaneity between causal and operational processes.

In conclusion, it appears then that causal structures include transitivity, reversibility and symmetry, additivity, multiplicativity, proportions, distributivity, composition of inversions and reciprocities, sufficient reason and coordination of actions and alternation of roles. Also by defining causality as an attribution of operations to objects, it means that causality remains in the current tradition of rationalism Piaget(1972). In the context of the stages outlined by Piaget, the relationship between Causality and Operational Thinking is portrayed as follows:

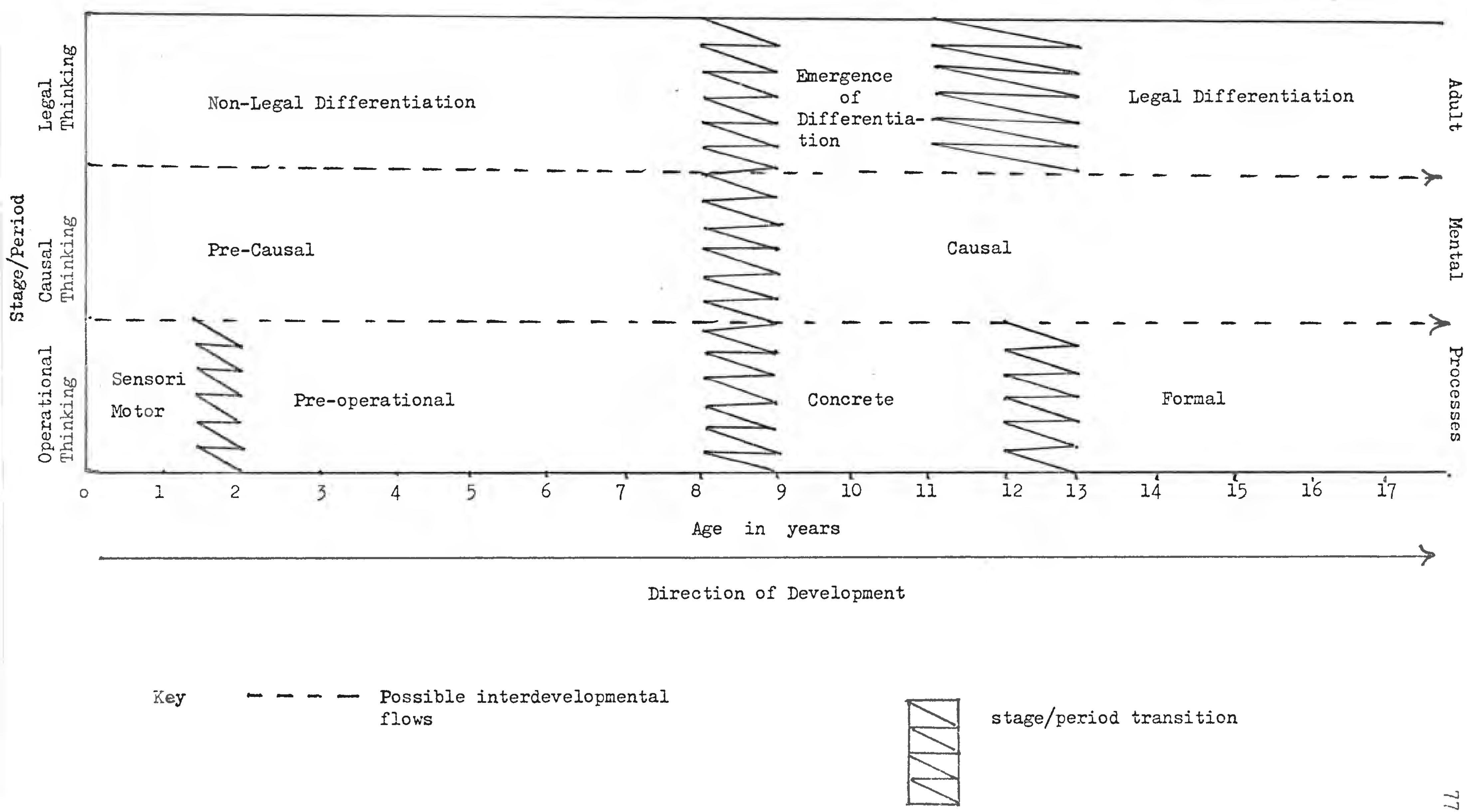
<u>Stage I</u> Every sensori-motor action is causal and at the outside very closely connected with a logical process. There is relatively little undifferentiation between causal, pre-causal and logical connections which means continuous interaction at the core.

<u>Stage II</u> Differentiation takes place but in case of weight it can only be logicised at a later period. Step-by-step compositions that limit mobility of operational structures here are due, to delaying influences of causality on operational thinking.

<u>Stage III</u> Differentiation of Causality and operations permit free progress of operations and of rather rich attributions ensuring a remarkable development of causality.

It seems that causality and operations have a common origin and are undifferentiated at the stage 1 level in children aged between 4-6 years. Causality depends on <u>action</u> whereas operational thinking depends on <u>coordinations</u>. Causality constitutes the "shuttle" game that in turn

Figure No. 2 Showing Interpositional Perspectives to Stages/Periods in Childrens' development of Legal, causal and operational thinking



constitutes the exchange of the subjects' operations with the real world. Therefore, it is difficult to tell when the deductive contributions of the subject begins and where those that result from the kind of immanent deductive construction (i.e. causal production) ends.

In causality, connections go beyond the frontiers of the observable, it includes necessary connections, it includes several relationships coordinated into a system, and this system alone is the source of necessity. In addition to, and because of the foregoing, causality is an attribution of the same operations to the Objects themselves.

In order to interpret causality as an operational structure applied to the object, a deductive link is able to effect extra-observability, necessary connections and a coordinated state of multi-relationships. Causality always includes a system of transformations that cannot be reduced to a single relationship of cause and effect, and that like all transformations express itself more or less adequately into real actions.

In conclusion to this section on the genetic epistemological view of causality, an attempt by the author has been made to bring together in the form of a schematic perspective in Figure No.2, the various strands relating to this view of causality and its use in explaining childrens' causal thinking.

CHAPTER 4

REPLICATION AND FURTHER DEVELOPMENT OF GENETIC EPISTEMOLOGICAL THEORY IN PSYCHOLOGICAL STUDIES OF CHILDRENS' CAUSAL THINKING

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INTRODUCTION

Since Piaget's pioneering work on childrens' appreciation of Physical Causality in the late 1920's there have been a growing number of studies on the subject. It is intended in this chapter to examine studies of children's appreciation of causality that have been mainly concerned with replicating or extending Piaget's work. The early studies concerned with Piaget's theory of development of causal thinking in children, are characterised by the fact, that such studies have been concentrated on the pre-causal period, and more specifically in the area of animism within this period. The review which follows, falls into two sections :-

4.1. Research aimed at replication, or part replication of Piaget's Studies on Causal Thinking.

4.2. Research extending Piaget's work of causal thinking into other psychological domains.

4.1 Research aimed at replication, or part replication of Piaget's Studies on Causal Thinking

Johnson and Jacey (1931-32) found no animism, artificialism or egocentrism in the thinking of 6 year olds. Askar (1932) found only a few instances of animistic thinking. Isaacs (1930) came to the conclusion that pre-causality was quite exceptional among children. Cross culturally Mead (1930), working among the Manio children, detected no spontaneous animism, while Jahoda (1958) has found few animistic expressions in African subjects. Also Deutsche (1937) discovered that 62% of explanations fell into mechanical and logical forms of explanation. Deutsche's findings were supported by Jones and Arrington (1945) and several studies by Huang (1930,* 1935,* 1943). In fact Huang and Lee (1945) reject animism in favour of a theory of differentiation, so that a child proceeds through a neutral to animate to inanimate process, and so the child's thinking is determinate. Later, Klingenberg (1957), using Huang's procedures, found similar results.

It appears that the sometimes severe criticism of Piaget's conception of Pre-causality, tends to centre around two factors, i.e. the exact meaning of the infantile nature of pre-causality and the concept of stage. Elaborating briefly on these factors, let us first consider the criticism surrounding pre-causality. The work of Hazlit (1930), Abel (1932), Huang (1943) showed that the way in which elements of pre-causal thinking were selected for study, meant that there was no difference between adults and children. Dennis and Mallenger (1949), and Dennis (1953) in their studies, showed as far as animistic thinking is concerned, a characteristic of pre-causality was also expressed in adults as well as children. Further studies, discussed in Laurendeau and Pinard (1962) also point to similar findings. **Lowrie on the basis of his work, refuses to see in answers given by his subjects, a manifestation of animistic thinking, as the Ss particularly mention errors arising as a result of ignorance of classification. However, Laurendeau and Pinard (1962), see animistic thinking differently for both adults and children. They elaborate further, by saying a large number of adult responses are obtained in the various studies, due to the poor availability of adult criteria.

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* Quoted by Laurendeau and Pinard (1962)

** Quoted by Voecks (1954)

The existence of stages is another area which has produced and is producing constant controversy. There are three main reasons given for the refusal to admit the existence of stages according to Laurendeau and Pinard. These are :-

(1) considerable overlapping

(2) continuity

(3) response inconsistency

(1) Considerable overlapping - according to Deutsche (1937), Bruce (1941), Huang (1943), all children should of the same age have the same intellectual maturity. Russell (1940a, 1940b) grouped subjects according to mental rather than chronological age. However Laurendeau and Pinard, who are ardent advocates of stage theory, view the concept of stage as having foreseeable overlapping in the age series, if the stages are really to reveal intellectual progress. However, mental age assessment as opposed to stagified indications of childrens' mental growth, disregard the dynamics of mental operational thought. Nevertheless, as plausible as Laurendeau and Pinard are in their defence of the stage concept, the point made earlier by Osterrieth (1955) and 22 years later by Brainerd (1977), that psychology did not as yet have enough empirical data to validate or invalidate a supporting hypothesis for the stage concept, intensifies the argument. Even Shayer's (1980) recent work and its criticism, Brown and Desforges (1977), Thomas (1981) is far from resolving this thorny issue. The criterion that so far, emerges as the most valid one for estimating a stage of development, is equilibration and this is perhaps not the most reliable in view of its rather vague nature.

(2) Continuity - The development of causal thinking would appear to be continuous without revealing gaps that the concept of stage suggests. A subject's progress from one particular stage to another, may be abrupt and changes do not always occur at the same moment for all subjects. Again the "spurts" are less evident in groups. A mean rhythm of evolution does not always reflect individual rhythms. Only longitudinal studies can provide such precise information on rate of progress via the stages.

(3) Response inconsistency which the studies of Deutsche (1937), Huang and Lee (1945), Klingen Smith (1953), Klingberg (1957) have raised. Piaget has called for a series of intervening stages, corresponding to levels of conceptualisation that come increasingly close to objective thinking. Laurendeau and Pinard (1962) state, that the real problem concerns the constancy in the sequential order of the child's various forms of behaviour. This constancy constitutes the fundamental character of any stage scale and is the most important among the 5 criteria constituting a stage :-

> ".......... in dealing with stages, the order of successive types of behaviour is to be considered as constant, that is, a given characteristic will not appear before another in a certain number of subjects, and after another in a different group of subjects. When there is such alternation, the characteristics involved therein cannot be used to identify stages"/Piaget* (1955)/.

So far, only the criticism of Piaget's work has been outlined, there is also much research supporting his work on causality. Laurendeau and Pinard (1962) have discussed at length most of the studies which lend support to Piaget's theory. They mention studies by Russell and Dennis (1939),

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* See Osterrieth et al (1955)

Russell /(1940a, 1940b)/ which support most of Piaget's contentions. In studies of animism, Klingen Smith (1953), Havighurst and Neugarten (1955) have found a high occurrence of the feature. Grigsby (1932) seems to have found all of Piaget's 17 types of causal explanation. Ausubel and Schiff (1954) report from their studies, that the younger the child, the easier it was for them to accept two concomitant phenomena being causally rolated. Towards the end of the 60's Looft and Bartz (1969), unlike workers quoted earlier, found that there was a difference between adult and children's animism. A recent study by Young (1980) on animism in British primary school children revealed that an overall level of animism was low for 5 and 7 year olds and almost non-existent for 9 year olds, giving further evidence of non-support for Piaget's account on animism.

Dennis (1943) went as far in saying that "pre-causal concepts are truly autogenous and universal". Perhaps, the most extensive study of causal thinking in children and which lends strong support, not only to Piaget's theory of causal thinking, but to the concept of stage, is that carried out by Laurendeau and Pinard (1962). They set out to verify the existence of pre-causal thinking, then to control the sequence of Piagetian stages, and finally to determine the age at which each stage is reached. They used as stimulus material in their questionnaires, topics like dreams, life, origin of night, cloud movements, floating and sinking. In choosing these topics their objective was to investigate to what extent realism, animism, artificialism, explanation and prediction were features in children's appreciation of causal situations. The ages selected ranged from 4 to 12 years and the number for each age range was 50. They controlled for sex, familial environmental and occupational levels including sibling numbers. Academic levels were also recorded, 5 questionnaires in all were administered. In analysing the results independent scales of responses or stages were prepared for each one of the 5 questionnaires. A calculation of median age located at one of the stages was performed. When the scale of median ages corresponded to the scale of stages - transitivity of various levels was assumed. These workers found that animism, artificialism and finalism are the most expressed beliefs. Another finding, was that children tended to use the same given type of explanation e.g. animism or finalism etc. Animism and artificialism seem to be preponderate forms of pre-causality among children and, moreover, the younger the child the more mixed are the five modes of explanation. The research of Laurendeau and Pinard also confirm the occurrence of primitive beliefs of a pre-causal type, however phenomenism was not clearly identified. Answers to each questionnaire fell into 3 main stages :-

(1) Pre-causal stage

(2) Invoking of pre-causal and physical or objective explanation

(3) No pre-causality

They also found that realism disappears at $6\frac{1}{2}$ years, artificialism at 9 years and animism around 10 years.

From this extensive and intensive study, Laurendeau and Pinard came to the conclusion that the <u>development of causal thinking consists in a progressive substitution of physicalistic interpretations for primitive beliefs that can be expressed in a stagified process</u>. Accession to a higher stage, pre-supposes at least a partial withdrawal from the preceding level. Schematically, the development of causal appreciation may be represented as follows:

Pre-causality --------> [Inter mediate phase] --------> Causality. Some of the features that Laurendeau and Pinard put forward as a possible area of further examination, was that transitivity as it affects causal thinking needs to be verified. That more exact limits of continuity should be defined. Finally, there is a need for longitudinal studies to follow through these findings and hopefully lead to their validity. The work carried out by these workers has been treated here at some length for the following reasons:

(1) It was a study that really tried to get to grips with the notion of pre-causality and its gradual substitution, by purely causal interpretations on the part of children.

(2) It was a fairly rigorous cross sectional design, which attempted to act as an essential framework for investigating causal appreciation in children.

(3) It was an investigation that concentrated on the stage concept and attempted within it, to earmark specific forms of childrens' explanation that characterised each stage or sub-stage.

(4) Methodologically, it was a great improvement on former studies of causality, in that it introduced much needed rigour into the instrumentation and the application of cummulative frequencies, to fit into a stagified process.

However, the investigation was perhaps designed with too much of a pre-conceived notion of stage theory in mind. Although, the authors do point out how the dynamic nature of children's thinking and the subsequent over-lapping between stages etc. are features that straddle across various stages. Frankly, the whole investigation is a "conceptual straightjacket" giving the reader an impression of staticism rather than dynamism. Freyberg (1966) draws attention to the discreteness of stages, and the fact that the stage hypothesis is questionable because of its inconsistencies with Piaget's central theory.

Freyberg goes further to repudiate the whole question of stage, in the way undesirable educational consequences could ensue i.e. the danger of having preconceived slots into which pupils should fit. These are certainly words of caution, when interpreting work of such ardent protagonists of the stage concept such as Laurendeau and Pinard. However, Ward (1971) carried out a partial replication and validation of Laurendeau and Pinard's study and investigated cross cultural differences among 3 age levels of Canadian, American and American Indian school children. These age levels were 6, 8 and 11 years respectively. Her findings supported Piaget, and Laurendeau and Pinard, in that three related stages of development were featured. Also, there was a similar manifestation of pre-causal forms to that found by Laurendeau and Pinard. In comparing the results between the different cultural groups, there was a significant difference recorded between age and school grade in American children, and the American Indians in all concepts except the life concept. It would appear even with the scepticism shown by workers, such as Freyberg and Brainerd, some confirmation for stage processes is present here. Up to the time of Laurendeau, Pinard and Ward's work on causal thinking, investigations of causality were in the main, related to physical causality and much of research was limited to childrens' pre-causal and early causal appreciation. Such studies, fall under the description of replication, partial replication or modified studies. Research by and large which post dates this period became more wide-ranging in that psychological causality among others, became a further field of interest in causal thinking. It is to these studies that we now turn.

4.2 Research extending Piaget's work of Causal Thinking into other Psychological Domains

Since the work of Laurendeau and Pinard, recent research into causal thinking has developed along at least two main lines. The first has been to examine the Piagetian framework for the development of causality in the child, and its possible relationship with other tests of ability e.g. standardised aptitude tests, practical causal demonstrations etc. Such work has employed factor analytic techniques in treating the results. The second line of research, is based on "attribution theory" which takes the study of causal thinking into the social psychological domain, and in which some of the studies reported in this section use psychological as well as physical causality as an area of research.

A study of causal reasoning was carried out by Berzonsky (1969), which represented the first attempt to study children's causal appreciation using Factor Analysis, 29 tests were applied to a randomly selected sample 84 in number and with even numbers of male and female subjects. The ages ranged from 75-87 months. The 29 tests included verbal tests of causality, hypothesized causal components, Piagetian concrete and formal operational tests, a measure of I.Q. causal demonstrations and a descriptive measure. All tests except for I.Q. were administered individually. Thirty variables were treated using a maximum likelihood factor analysis with a varimax rotation. Five factors emerged, these were labelled by Berzonsky as follows:

Factor (1) Causal reasoning

(2) Concrete operational thought

(3) Problem solving ability

(4) Causal explanation

(5) Understanding of force

From a detailed analysis of the loadings,Berzonsky exptrapolated the following:-

(1) five component abilities were related to the ability to reason in a naturalistic manner

(2) that language had an important part to play in causal reasoning

(3) scepticism and "point of view" was considered important in understanding "cause" and "effect"

(4) relational thinking, verbal seriation "and so" discordance, failed to load on the causal reasoning factor and bore little relationship to types of causal explanation; however Berzonsky concluded that they might be important for scientific accuracy.

(5) High loadings on Factor II give support for Piaget's theory of concrete operational thinking

(6) Significant loadings on Factor III were recorded for pendulum demonstrations and chemical combinations and so indicated a problem solving factor

(7) Berzonsky found no support for Piaget's theory that pre-operational thought leads to pre-causal explanation, and no support for Piaget and Inhelders theory of the unitary nature of logical thinking

(8) Berzonsky finally concluded that at least three relatively independent abilities are involved in logical thinking

Berzonsky's work is significant in that it is a marked departure from the essential but "hum drum" replicative studies that pre-date his work. Furthermore his findings showed that :-

(1) pre-causality and pre-operational thinking were not related and this is an important factor to bear in mind in view of Piaget and Inhelder's (1973) stance mentioned in Chapter 3;

(2) apparently three independent abilities are involved in logical thinking of which Factor I is a causal reasoning factor indicating the primacy of causal appreciation at this age.

On the other hand;

(3) the high loadings on Factor II for concrete operational tests show that the primacy of operational thinking is however not far removed; Factor III is the third ability i.e. Problem solving.

(4) finally, Berzonsky's work adds further dimensions to the study of causal thinking like the role of stimulus familiarity, language ability, social measures i.e. verification, scepticism, which Piaget either ignores or plays down in their influence on operational thinking.

Berzonsky (1973) in a further study in which he used again a factor analytic approach to investigate a child's animism analysed 33 variables on 83 first grade children and found an "animism factor" involving children's conception of life. Animism was found to be relatively independent of operational thought, Piagetian type problem solving and an ability to give causal explanations of physical phenomena. A second study reported in the same reference in which eleven variables were factor analysed, showed that a similar animistic factor emerged. It was furthermore shown that animistic conceptions were unrelated to childrens reasoning about interpersonal situations e.g. morality, justice, psychological causality etc. So here we have another study, in which a specific technique like factor analysis, has shown that Piaget's theory of the unitary nature of intellectual development has little support. Moreover the view that cognitive development may be an all-pervasive "g" factor (Flavell 1970) was also not supported.

The study casts doubt also on a positive relationship between a pre-causal attributes like animism and pre-operational thought which once again is at variance with Piaget and Inhelder's recent stance. In another study Berzonsky (1973a) applied measures of psychological causality, morality, justice, physical causality, scepticism, animism and perspective tests to 41 first grade children. An orthogonal rotated principal components analysis indicated 4 factors. The Factors I - IV were identified as social judgement, psychological, physical causality and conception of Life factors respectively. His findings revealed support for Piaget's views that the attribution of physical and psychological causation have different bases and sources of origin. Whiteman /(1967, 1976)/, Kelley (1972 1973) showed how "attribution theory" can provide us with a guide enabling people to make more meaningful causal explanations especially in psychological causality.

Investigations linking attribution theory with physical causality have also become evident. The work of Schultz and Mendelson /(1975, 1976)/ is pertinent in this respect and will be dealt with presently, and again in Chapter 5. Although on the surface, studies of psychological causality may seem to have little bearing on the present investigation the work of Whiteman /(1967, 1976)/ is valuable inasmuch as it :

(1) Provides a further perspective to the study of causal thinking - in this case a social one;

(2) it is the first attempt to examine the relationship and origins of psychological as well as physical causality;

and finally

(3) that Whiteman's 1976 study examined possible mediating abilities of a physical - logical nature which might account for age differences.

With regard to (2) above it appears that the origins of psychological and physical causality are separate. As to point (3) Whiteman showed that measures of physical-logical ability are independent of interpersonal cognition, but that this problem is not an easy one to delineate, and reflects therefore some of the fundamental issues discussed earlier relating to causal and logical thinking (see Chapter 3).

The nature of causal thinking has also been enriched by the work of Schultz and Mendelsohn (1975). They have explored the way children select a possible cause that gives rise to a particular effect. They used "the covariation principle" of causal analysis as recently expressed by Kelley (1973) in Attribution Theory. The principle specifies that an effect is attributed to one of its possible causes with which it covaries. Schultz and Mendelson (1975), used children aged between 3 and 11 years, who had to observe fairly elaborate pieces of apparatus, that produced physical effects such as flashing coloured lights, bells ringing, magnetised action and to account for their possible causes. Their results showed that 3 year old children were capable of using covariation information in their attributions of simple physical effects. Children aged 6 - 7 years had greater difficulty in identifying inhibitory causes than identifying facilitating ones, while 9-11 year olds identified the 2 types of causes with equal accuracy. They also found that older children appeared to assume that causes preceded effects.

Although the apparatus and the procedures used in Schultz and Mendelson's work is unnecessarily complicated, the study does give another dimension to the whole area of causal thinking namely, causal plurality and is pertinent to this investigation, which also looks at plurality in causal situations.

In a second study Mendelson and Schultz (1976), observed a physical effect in 4-7 year old children which could be attributed to either a consistent but non-contiguous covariate, or a contiguous but inconsistent covariate. Their results showed, that neither consistent covariation nor strict temporal contiguity were essential aspects of causal inference for these children.

As these workers point out, it is hazardous to conclude anything about the relative importance of covariation and temporal contiguity from these results. Either principle may be operating under various conditions. However the real question of how do children know when to apply either principle still remains. Perhaps, there is yet another element in the way children infer and eventually explain causes?

This recent study by Mendelson and Schultz, although possibly over complex in the methods and apparatus used, does provide further evidence of the complexity of childrens' causal explanation. It also raises the problem of what are the mental structures involved in causal thinking, and the role they perform when children are to explain causal phenomena?

In conclusion no studies to date concerning causal thinking and memory processes have been carried out by workers other than Piaget and Inhelder (1973). But from their investigations, memory factors are obviously crucial in various stages of causal appreciation and comprehension. More and more studies have tried to assess the role of variables like language, relational thinking, material familiarity, methodological and procedural techniques (see Chapter 5 for fuller discussion) and even the role of social attitude in children's explanation of causal situations. In the case of language studies and thinking, relationships have been shown to exist e.g., question wording which plays no small role in influencing causal thinking. Furthermore, physical causality which dominated the scene before the mid 1960's, now shares the stage with research into psychological causality, and it appears that Piaget's views on the origin of physical and psychological causality are supported by recent research.

Finally, the application of a social psychological theory namely "attribution theory" or a "behaviourist" construct such as "temporal contiguity", has shown that there are other perspectives to causal thinking. These perspectives provide us not only with a fresh conceptual view to causal thinking, but show how some of the methodological problems concerned with cognitive development in general and causality in particular can be approached. It is to these methodological aspects of researching causal thinking, that we now deal with in the next chapter.

CHAPTER 5

PSYCHOLOGICAL PERSPECTIVES TO THE STUDY OF CAUSALITY WITH REFERENCE TO METHODOLOGICAL ISSUES

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INTRODUCTION

This chapter will consider some of the important methodological problems and issues encountered in former studies of causal thinking. Previous research will be discussed under three broad headings:

5.1 Language factors

5.2 Experiential factors and the nature of the stimulus Material

5.3 Experimental and Procedural Factors

5.1 Language factors

Research related to language and causal responses elicited by children at different ages, can be said to cover two main aspects; the nature of the question; and the nature of the response to that question. However, it may be useful before examining the studies concerned with question wording, to refer to Piaget's work on language, and thinking and children's conception of the world, especially with reference to the use of interrogatives that elicit causal responses. Piaget (1929) indicated that a question having a "What makes ......" introduction, tends to suggest to the respondent an operation of naturalistic forces e.g. mechanical and could obliterate tendencies to express animistic explanations. Again Piaget (1926, 1975) states that the use of the interrogative "why" seems to produce more affective than intellectual responses. As to the "why" form of questioning, it seems to have been a fairly common occurrence in many studies of causality and an interrogative that Piaget himself has used quite often. Such a feature may well be directing the child's response to looking for a purpose in the particular causal situation. The early work of Huang (1945), Isaacs (1930) and Oakes (1947) suggests, that the manner in which a question is worded, can influence the type of response obtained. These issues were taken up by Nass (1956), in which he attempted to empiricise Piaget's work, and much later by Palfrey (1971/72).

Nass put forward a research question that tried to relate the wording of questions to children's level of causal appreciation. The research question was, "Does the form or wording of questions regarding physical causality have an effect on the childs responses? 120 subjects, half designated "emotionally disturbed", the remainder normal, aged between 8 and 10 years were given two forms of question wording. These were (i) "Why does ....", (ii) "How does ...." and were used with statements probing causal situations. The results obtained by Nass, lent support to Piaget in that causal material of a remote experiential level and probed with "Why" interrogatives, gave a greater percentage of pre-causal or non-naturalistic responses than those elicited by "How" questions. The "How" interrogatives gave more naturalistic responses. Some years later, Elitcher (1967) took up the variable of question wording and related it to children's causal thinking as well as cognitive style. 136 subjects between the age of 8 - 10 years were examined using an individual interview method. Elitcher used "Why" and "How" forms, and scored the responses in the same way as Nass, i.e. Naturalistic, Phenomenistic and Non-Naturalistic. Her results confirmed Nass's findings. So it appears that "Why" and "How" interrogatives seem to have a significant influence in the way children below the age of 10 years respond to questions about causality. Berzonsky (1971a) argues that the use of questions beginning with "What makes ....", provides a more suitable form of wording, as it provides a suitable substratum for naturalistic type explanations in children, who should be capable of explaining causal phenomena in this way. Therefore it is clear, that careful selection of the appropriate interrogatives are important in developing instruments probing causal thinking, a point that has received considerable attention in the author's pilot studies described and discussed in Chapter 6.

A growing area of interest is the response side of the experimenter - subject interaction. The work of Piaget et al (1968), Mogar (1960), Peel (1965) relates to the composition of the response or explanation elicited by questions. More recently Corrigan (1975), Biggs (1980), Harlen (1979), Thomas (1980) have shown how complex the nature of childrens' explanation can be, whether it is specifically causal or not. Some discussion of the work of these authors will follow as their approaches to the problem of explanation are pertinent to parts of the present investigation. The earlier work of Mogar (1960) in which she examined children's causal reasoning about natural phenomena showed how she concentrated on childrens' explanations. She developed a 7 point rating. A rating of 7 involved a correct and complete answer, a 6 was a correct but incomplete answer, but a fair explanation which included some sense of the principles involved. A 5 rating was given to a fair explanation with some sense of the principles, a 4 rating given to poor and vague references to principles, a 3 was given to an incorrect rating and 2 and 1 were given respectively to repetition of the phenomenon and a non-naturalistic response. Mogar's work appears to be amongst the first attempt to supply guidelines for the categorisation of childrens' explanation, and while the criteria used are somewhat indeterminate, especially at the 5 - 6 - 7 end of the rating scale, it is a valuable approach in analysing and subsequently quantifying children's causal explanations.

Peel's (1960,1965) work on adolescent thinking, also takes up the explanation of causal situations and the general issues underlying children's explanations. He used simple contrived situations derived from problems met in school. His emphasis was directed towards the quality of thinking rather than attainment.

In analysing the main features of intellectual growth between eleven and twenty years of age, Peel puts the nature of <u>the response</u> as a very central feature. Descriptive thinking is seen at one end of the continuum with its emphasis on particularistic perceptual and circumstantial processes, While at the other end, the mode of thinking is articulate in the use of deduction and elimination of alternatives not related to the particular situation in question. He makes what seems is a distinction, and apparent evolution from <u>descriptive</u> responses to <u>an explanation</u>, and thence to a very sophisticated mode of explanation. The present author would take issue with Peel that <u>description</u>, even if it is a one word affair is a form of explanation for <u>that</u> particular child or adult. Description is part of the continuum which constitutes the whole process of explanatory behaviour, for it only needs secondary and tertiary probing with many children to reveal more about the nature of description.

However, Peel has shown in his valuable contribution to the nature of childrens' explanation what a central role explanation has in interpreting different levels of intellectual growth. Furthermore, in discussing the etiology of changes in thinking and subsequently its expression through an explanatory process, Peel makes an important point concerning the role of teaching in the use of language. For teaching it seems would improve the whole process of learning to think and presumably influence the level of explanation. Piaget (1930, 1968) has also paid much attention to both causal explanation and explanation per se. In Chapter 4 the various forms of pre-causal and causal explanations were discussed. These will not be mentioned further here, but in a general discussion on methodological aspects of causal explanation, Piaget et al (1968) has provided the researcher, who is concerned with analysing children's explanations, useful conceptual guidelines. The ideal in causal deduction is a deductive argument applied to the production of phenomena. According to Piaget the argument is all the more useful when the deductive steps correspond to the links between the subject material. In other words, the order of the explanation reflects that of the antecedents and consequences. Piaget, further characterises explanation by referring to two central features of causality namely :

a) necessity of relations between causes and effects

b) the reality of the causal tie underlying the measured phenomena.

In developing a methodology for assessing explanatory behaviour in the first place and causal explanatory behaviour in the second, this central direction given by Piaget, although somewhat complex is a useful theoretical basis for a more meaningful analysis of explanation. This basis has to some extent been taken into consideration in some of the research problems posed in the present investigation.

The work of Corrigan (1975) will receive more detailed discussion later on in this section, but perhaps it needs to be stated here, that work of the type carried out by Corrigan examined the syntax and the comprehension of causal explanation. It also reflected the whole issue of <u>performance</u> in the use of causal language, and <u>competence</u> in understanding and explaining the underlying causal mechanisms exhibited by young children. From this standpoint her work is extremely valuable, as it presents us with the finer details of explanatory behaviour in general, and causal explanation in particular.

The work of Biggs (1980, 1980a) also concentrates on the nature of the response, but he is much more concerned with response quality as a result of learning outcomes. However, as he points out; in essence two interrelated sets of constructs are involved in childrens' responses. These are developmental stages which are called hypothetical cognitive structures (HCS) and actual response of pupils which may display elegance, deftness, information etc. and are called the structure of observed learning outcomes (SOLO). Further reference to the interrelationships between HCS and SOLO will be made in Chapters 11 and 12. However, what needs to be said at this point is that the way Biggs has looked at pupils' explanation is not only interesting but is a welcomed trend in its analysis. Five descriptions of SOLO are indicated which interrelate with the basic stages of cognitive development. The five SOLO descriptions are in essence levels of explanations, and are briefly:

(a) Extended abstract which includes, deduction, induction, generalisation from formal statements to non-experienced situations.

(b) Relational; this includes induction but no deduction that has elements of generalisation and conclusion.

(c) Multi-structural contains induction and elements of generalisation.

(d) Unistructural - includes mainly induction and some generalisation.

(e) Pre-structural - is considered to contain non-logical, denial tautological and guessing type expressions.

Although the work of Biggs post-dates the research carried out on explanation in this investigation, it nevertheless has pertinence to some of the findings discussed later.

Harlen (1979) has also examined the responses of children to certain questions in "The Progress in Learning Science Project". The project attempted to draw attention to particular aspects of childrens actions and responses. In investigating the ability of finding patterns in observations, the statements suggesting various progressive levels of development. One of the attributes appearing in Harlen's check test was cause and effect, and her analysis of childrens responses related to these notions were described as follows:

(1) There is an acceptance by the child that things happen and that mechanical things work without seeking for a cause, or there may be a suggestion of reasons in terms of fantasy or mystery.

(2) Gives explanations in terms of the presence of some component or feature, which may play a part in the process but is not itself the cause. There is a difficulty in predicting what the child thinks may happen when certain changes are made.

(3) The child may seek to explain physical effects in terms of physical causes, even though the correct causal relationship may not be found. There is a use of the cause - effect relationship observed to suggest what will be the result of certain changes.

In the first case (1) the child goes little beyond the straight description containing a minimal sign of any causal appreciation. In the second case (2) the child gives a causal description but often combining patterns not justified by the evidence. Finally the third case (3) an attempt is made by the child to find patterns justified by what has been observed. Harlen's work therefore shows once again, the current research emphasis on the way children explain phenomena and in this case causal phenomena. Harlen's approach which is near to that of Thomas (1980) may be considered somewhat normative and related more to "developmental levels". However it can furnish the worker in the field who is interested in probing the mechanics of children's explanation, with a valuable insight into childrens thinking patterns, especially causal patterns.

From the various observations and categories of explanations both causal and non-causal, let us move on to more syntactical considerations of the causal explanations themselves. Of particular interest to the study of causal explanation the use of certain connectives is salient. Numerous causal connectives may be used in constructing causal explanations "but", "although", "as", "because", the latter one being the most common. Piaget (1924, 1969) described three ways in which children use because:

(a) Pre-logically; in which clauses are randomly juxtaposed, here the two clauses that were joined do not have an explicit relationship. Another form of this is when two clauses have a psychological relation i.e. one clause describes an action and the other a motivation, e.g. "Jane punched Pete. Pete cried because Jane hurt him".

(b) Causal Relations - in which "because" is used to connect two events; one event being produced by the other, e.g. "Karen was sick, she stayed home from school because she was sick".

(c) Logical Relations - in which two ideas or judgements are connected so that the clauses describe logical relation or implication, e.g. "All the blocks were white. Jon had a white block because there were only white ones".

In doing this work, Piaget initiated a valuable awareness in the use of a connective like "because". The work of Vygotsky (1962) and Werner and Kaplan (1963) showed that such connectives are important in abstract thinking but all these workers had studied usage of these connectives in languages other than English, Vygotsky in Russian and Werner and Kaplan in German. This state of affairs, stimulated Katz and Brent (1968) to carry out research to differentiate between levels of understanding, and to account for discrepancies between a child's spontaneous and deliberate expression of relationships in the English language. They studied (1) correct usage in spontaneous speech (level 1), (2) selection of appropriate usage in a paired sentence test (level 2), (3) ability to explain the formation of connectives in the sentences on the test (level 3). The Ss included Grades 1 and 11 school children, and college students as a control. Level (3) provided the most important differences between the two age groups. It was also found that Grade 1 S's were able to differentiate correct from incorrect. However, when it came to describe the role of the connective in specifying relationships, these children were unable to do so. In the use of so called adversative connectives like "but" and "although" it was discovered that they provided greater problems of mastery than the use of "because".

Finally, Katz and Brent found that trends for linking causal clauses by means of causal as opposed to temporal connectives were preferred e.g. "I lost my keys therefore I could not get into the house" [Causal]. Also a preference was shown for ordering causal clauses, where there is a correspondence to the actual perceptual order of events, e.g. "John did well in school and he studied hard". However, these authors do not give sufficient examples, and therefore convincing evidence, of why it is so. This in turn, indicates a serious omission in their work, in accounting for the developmental trends they discuss. Corrigan (1975) attempted to test the developmental sequence of the three types of Piagetian "because" mentioned earlier. She used 9 tests with 100 children aged 3 - 7 years. Her tasks tested whether comprehension of because preceded its usage, and at what point children understood that sentences with reversed clauses were incorrect. Using scalogram analysis, she found that comprehension of each type of task preceded usage of that type. Sentences with reversed clauses were more difficult than either comprehension or so-called "usage" items. Her findings firstly, supports the work of Piaget and secondly, the experimental studies carried out by Katz and Brent, as well as that of Ferriero and Sinclair (1971), in which pre-operational children prefer temporal links rather than causal ones. The work also provides further support to the Genevan position on this point. Corrigan's study also suggests that an ability to understand the problem with reversed clauses and the ability to use the concrete logical "because" reflects the concrete operational stage.

Lawton (1977) examined the use of causal and logical connectives using pre- and post treatments based on Ausubel's concept of advanced organisers in social studies lessons. His subjects numbered 120, ranging from 6 - 10 years of age. The use of syncretic reasoning and understanding, decreased following the experimental treatment. The study is useful in the context of the present investigation, as improvements reported by Lawton in the use of causal connectives occurred as a result of experiential factors namely, a specific teaching treatment, and which meaningful receptive learning was considered to have brought about a qualitative change in thinking.

Berzonsky (1969) examined the language factor in a Factor Analytic Study of 84 Canadian children aged 6 - 7 years. He included the language factor as a sentence completion task which was part of a hypothesised causal components list. Children had to complete sentences verbally using the connectives "because", "and so", "but" the latter connective signifying some discordance e.g. "Jane dropped the jar but ...." Berzonsky found Factor 1 to be a causal reasoning factor and on which "because" statements loaded. Factor 11 was identified as a concrete operational factor and contained "but"statements together with mental seriation, perspectives tasks etc. Apparently, ability to complete discordant "but" sentences, requires a type of mental agility or ability to decentre; analagous to an operational mental reversibility. From Berzonsky's results it appears that the ability to complete a statement of cause and effect is related to causal reasoning. Although it should be said, there is more than a subtle difference between completing a sentence task and actually constructing one - a point taken up later in this investigation. Similarly, this language ability is also related to the child's capacity to appreciate concrete operational thinking. As perhaps expected, the language factor especially in the case of causal connectives is closely related to the expression of causal appreciation. However, from the literature just discussed, the various causal connectives are differentially related to the way children at various levels of intellectual development use them.

"Because", is the most common in causal statements and also the one children find easiest to master, use of "but" and "although" are more difficult. An interesting trend seems to be that pre-operational children prefer temporal links rather than causal ones. It appears however, that the use of causal connectives improves as a result of teaching exposure. Finally, there is more than a tenuous link between the ability to express causal appreciation and reasoning ability, particularly causal reasoning ability.

Summarising from what has been said about the role of language in detecting the nature of causal appreciation, research on the way questions are posed with regard to the interrogative, shows how crucial it is to select the appropriate interrogative, if one is to obtain the best level of response. It may be however, that selection of the appropriate interrogative has only a critical response value below a certain age. For instance, in the author's pilot studies where three groups of children aged 9 plus were each exposed separately to "what", "why" and "how" questions, few differences were obtained in the nature of the response. Except that "What" questions marginally produced more naturalistic and somewhat more substantive explanations.

Of equal importance in considering the role of language into researching childrens' causal thinking, is the type of response or explanation that might be predicted. Recent research into this area concentrates on the analysis of childrens' responses, and it appears that the development of guidance schedules may be useful to give the researcher a better indication of the level of causal appreciation, and eventually a more realistic measurement. It is an issue that this investigation is closely concerned with and will be discussed at length in subsequent chapters.

5.2 Experiential Factors and the Nature of the Stimulus Material

Closely related to experiential factors such as SES, schooling culture and religion, is the nature of the stimulus material presented to children in order to probe the appreciation of causality. The interactive nature of experiential factors presents considerable methodological problems to the researcher, in trying to unravel and trace the differential effects that some of these experiential factors have on causal appreciation. However, central to the whole area of experience, is the familiarity or otherwise of the stimulus material, and this has received more attention from research workers in the area of causality than the role which experiential factors. e.g. SES may play in influencing familiarity. Therefore, research into the familiarity of stimulus material as it relates to causal appreciation will be considered principally in this section.

There appear to be various interpretations of what familiarity refers to in different studies. Sometimes familiarity may refer to the number of times a child meets the phenomenon in question. The work of Grigsby (1932), Oakes (1947) have dealt at some length with this area. Baldwin (1955) and Russell (1956) have also commented on this subject, and they suggest that children revert to non-naturalistic causal explanations e.g. magical, animistic etc. when these children are unfamiliar with a phenomenon without presumably meaning familiarity in terms of frequency of encounter with an object etc. Another set of studies, Deutsche (1937), Grigsby (1932), Huang (1943) also raised the question of what experience a child brings to bear on his appreciation of a causal phenomenon. To these workers, it is a crucial determinant of that appreciation. Presumably, these writers see experience as a familiarity phenomenon and interpret on some basis of the frequency of encounter. Some workers like Nass (1956) and Berzonsky [(1969) (1971)], see familiarity in terms of a child's possible experience with the actual agency of causality. Both these workers included in their protocols, examples of familiar items like motor cars, bicycles etc. whereas their non-familiar or remote items included clouds, shadows and waves etc.

Siegler and Liebert (1974) widened the debate on material familiarity or non-familiarity, by suggesting that explanation of familiar or remote experiences may not only be the result of "physically based reasoning". It may be a reliance on authority, either at school or at home, and in order to provide totally unfamiliar situations, these workers examined the effects of contiguity, regularity and age on children's causal inferences using a "novelty type" situation. They compared 5-6 year olds with 8-9 year old children, employing a somewhat cumbersome and over complicated experimental apparatus, which emphasizes the "novelty" aspect. They found that contiguity affected the causal statements of each age group, and regularity influenced the statements of older children but not younger ones. Piaget's findings were supported, in that any contingency that increases the likelihood of temporal contiguity between events, also increases young children's tendency to infer causal connectives. On the other hand, factors independent of contiguity i.e. regularity would not be expected to exert any influence, and indeed this was the case. These authors argue further, that younger children's causal reasoning is not qualitatively different from older ones, but merely slower. Siegler and Liebert's work on familiarity, gives further perspectives to the relationship between familiarity and causal thinking. They attempt to provide "novelty" situations as well as presenting practical as opposed to purely verbal experiences to the child. However, one wonders about the use of such a complicated apparatus, which may suffice the "novelty" dimension, but to the author's mind, sacrifices what qualitative appreciation and explanation children may give of causality.

5.3 Experimental and Procedural factors

As in most Piagetian research, the designs and various procedures used by researchers for the study of causality have been mainly cross-sectional ones. The reader is referred to accounts by Huang (1943), Laurendeau and Pinard (1962) for substantial reviews of how these studies were designed and planned. Generally speaking, all research reports are of the clinical interview method, and like all Piagetian research did not employ controls, that is, the child is its own control. Even in the more recent studies, such as those of Berzonsky [(1969), (1973)], the design has been cross-sectional and the clinical interview formed the basis to the experimentation. Methodological problems arising out of this type of design are common, irrespective of the Piagetian notion studied, and have been adequately discussed elsewhere. In this particular investigation, only one age group was tested namely 9 year olds and followed up over 14 months, so problems concerned with a cross-sectional design did not arise. However, as part of the present investigation is longitudinal, it is necessary at this point, to refer to the literature, relating to this type of design. Unfortunately, longitudinal studies of causality are rare and those that exist have used mass testing procedures, Freyberg (1966), Dudek and Dyer (1969), as opposed to clinical techniques as employed in this investigation. However, the work of Piaget and Inhelder (1973) on mnemonic factors and causal thinking, may be described as employing a "half-hearted" longitudinal approach; "half-hearted" in the sense that it lacks the rigour of a well constructed longitudinal design e.g. no control for practice effects etc..

Hindley (1972) has usefully described the advantages of longitudinal research by raising a series of major questions that can be asked about development and examining the extent to which a longitudinal approach is necessary. The gist of these questions are as follows:

(1) how a function varies typically with age, in this case it is not necessary to employ a longitudinal approach as cross-sectional data is all that is required;

(2) in a question of researching individual differences during the course of cognitive growth, a more detailed picture of such a course would be provided by employing a longitudinal design. It could reveal more information about an individual status at different points in time;

(3) another question raised by Hindley, was the relation between earlier and later status, and in this case a longitudinal approach is necessary for deriving correlational evidence,

finally,

(4) a question was posed involving the study of factors affecting development e.g. culture, socio-economic etc. Here, longitudinal research could provide more valid causal information than cross-sectional designs can. However, Schaie (1965) has proposed a general model from which cross-sectional and "longitudinal hybrid" could be derived. In his proposal, Schaie suggests that a response is a function of age, special population and environment. Schaie defines age as chronological age at the time of occurrence of the response to be measured.

The special population is termed a cohort i.e. children born at the same time. His term environment is taken as time at which the measurement occurs and not the total environment. Schaie also goes on to state these factors are not independent, but they exhibit various forms of interaction

Schaie (1965, 1970). Baltes (1968) has on the other hand, proposed a more simplified alternative way of carrying out longitudinal research. Baltes proposes a bifactorial model using only the components of age and cohort. This bifactorial developmental model can be conceptualised as a design with independent as well as dependent measurements over the factor age. He then advocates that an application of an analysis of variance design aids the separation of the main effects of age and cohort and their interaction.

Schaie considers the "cohort - sequential" method as the general case of the longitudinal method in which two or more cohorts are studied at two or more ages. However it should be pointed out that several possibilities exist for error to creep into the design. This is due to the fact that measures of subject variables are repeated over a time interval. These errors are as follows:-

(a) Magnitude of change and time interval - if the change is large and the interval of time is long, then the advantage of using a longitudinal method over the cross-sectional is lost.

If however, the time intervals are small and the rate of change likely to occur in a particular variable can be estimated, then provided there is sufficient repetition of testing, the essential smaller changes so crucial for a longitudinal study of development to discover, are likely to be detected.

(b) Selective Survival, sampling and dropout are all potential sources of error and are determined by economic factors, social conditions and the personality traits of Ss and experimenters alike, especially in a large scale longitudinal study.

(c) Generation Effects - This factor is treated in detail by Schaie (1965) and Baltes (1968). It is important to control for this error source if possible, as cultural or environmental change if it occurs slowly, may have a marked effect on the dependent variable over several years.

(d) Testing Effects - Repeated measures designs are susceptible to practice effects where testing is carried out over short intervals of time. However, some control can be practised by drawing small samples at each testing of other previously non-tested subjects of the same age. Versey (1974) has shown that this method can work most effectively. In following this type of control one has the advantage of cross sectional checks on the progress of a group. However, as pointed out in Chapter 7, control groups tested at the pre and post test levels of a 3 or 4 or more test design are likely to reveal more about the intervening practice effects for particular Ss, than the drawing of small independent samples.

Lunzer (1960) has criticised much of Piaget's work, in that Piaget is content to argue the relatedness of different processes from their tendency to appear at the same time on different Ss. Later on, both Wohlwill (1963) and Freyberg (1966) raise similar points with regard to longitudinal research questions. Questions such as whether or not the steps marking the development of a concept appears according to a fixed and orderly progression. Again, whether responses to tasks which differ but which according to Piaget are based on the same mental operations etc.. Wohlwill has suggested that longitudinal research could be carried out in relatively short time spans. In an earlier study, Wohlwill (1960) advocates that by applying a scalogram analysis to cross sectional data, it provides one with data not substantially different than if longitudinal data had been obtained from the same samples over time. Versey (1980) has discussed at length the literature on former longitudinal studies carried out on Piagetian cognitive development, and has classified these studies under five sections : (a) sensori-motor, (b) pre-operations and concrete operational stages, (c) formal operations, (d) mental retardation and (e) Educational Experience and Cognitive Development. From an examination of these five sections a number of points arise that are pertinent to the present study.

1) Longitudinal studies have mainly been carried out within the age range of 4-10 years i.e. from pre-operational thinking to the final stages of concrete thinking. Within this range there has been a concentration of studies on the "magical" transition stage of 5-7 years.

2) Major questions which researchers have investigated have involved the sequencing of stages, the synchrony/asynchrony problem and the discontinuity and continuity hypothesis.

3) It seems in the main, that there is general agreement in the sequencing of sensori-motor stages but disagreements on the number of levels. It also appears, that the factor of "differing environmental backgrounds" when large samples are used, influence rate and time of achievement in the various sequences.

4) Very little faith is put by workers such as Bearison (1975) on what role experience, through instruction has, to give lasting ability in order that children may begin to think operationally.

5) Longitudinal studies into pre-operational/concrete thinking differ in many ways in which they approach specific problems; for example, differences occur in the way children are sampled, tested, assessed etc., However at the macro-level, the performance of a child is likely to maintain his status vis-a-vis the whole group and where similar sets of tests are applied.

6) Individual variations increases within closely related concepts, indicating more idiosyncratic developmental patterns.

7) Effects of social environment also seem to radically alter patterns of development.

8) Educational experience appears not to alter the rate of development greatly in "normal" samples.

9) A major fundamental problem, is the lack of statistical techniques to deal with the difficulties of retrospective repeated measures. This is a particularly difficult problem in using ordinal scales and dichotomous measures. Versey advocates the use of scalogram analysis prior to the application of multi-dimensional scaling.

In summary, it appears that any longitudinal study of cognitive development using Piagetian approaches, should take note of the facts that sequencing of Piagetian stages are fairly well established, that social and other cultural factors seem to have more than a cursory role in determining the performance of children on cognitive developmental tests. A problem appears to exist in the way longitudinal data is treated; the repeated and retrospective nature of such data pose particular problems when much of the data is expressed nominally or dichotomously. Perhaps a more serious implication of recent longitudinal studies is the negligible role any form of education and training has in "spurring on" the development of logical thinking.

The foregoing discussion on design features, and particularly the use of longitudinal methods, provides an important background to the present study of causal thinking.

BRIEF OVERVIEW

The review of the pertinent literature on causality has attempted to draw together three main strands:

(a) The Philosophical and Scientific Perspectives to the Study of Causality.

(b) Theoretical and Empirical Issues related to the Psychological study of Causality.

(c) Methodological Issues related to the Psychological Study Causality.

In examining the above, it is clear that a number of areas could be considered for further study in the context of children's intellectual development. Some of these will be briefly referred to below:

The literature on the philosophical and scientific perspectives to a study of causality shows that the causal principle is but one of several that can be used to explain physical phenomena. The modern generative conception of causality and the alternative notions put forward by Wartoffsky, provide interesting and fruitful areas to investigate in the context of science education.

The theoretical and empirical work carried out by Piaget and other workers establishes a valuable meeting point for psychological, philosophical, scientific and educational studies on how we explain the happenings around us. Of particular interest to this study, Piaget's theory of how children develop their appreciation of causality provides a valuable base from which to proceed. However, persual of the literature reveals that the majority of studies have concentrated on the ages between 3 - 8 years and have concerned themselves mainly with animistic thinking. Very few studies have probed mechanical and logico-deductive causal explanations in any depth and even less studies have followed up such explanations longitudinally. Depth studies into causal explanation and a longitudinal follow up would seem therefore to be not only worthwhile but essential in the context of science education with which the present study is partly concerned.

The relationship between causal thinking, memory processes and operational thinking also provides interesting sources of research and as the literature indicates, this work has received particular emphasis in the mid 1970's by the Genevan school.

An increasing amount of research has also been carried out on the factors that may influence causal thinking, e.g. stimulus familiarity, use of certain language structures etc.. However, little of substance seems to have been done on the assessment and categorisation of children's causal explanations and little on teaching of causal situations and its effect on children's explanatory behaviour.

PART TWO THE PRESENT INVESTIGATION

CHAPTER 6

THE PILOT STUDIES, AND THE RESEARCH PROBLEMS AND HYPOTHESES FOR THE MAIN INVESTIGATION

CHAPTER 6

THE PILOT STUDIES, AND THE RESEARCH PROBLEMS AND HYPOTHESES FOR THE MAIN INVESTIGATION

INTRODUCTION

Some of the potential areas for further research into causal thinking mentioned in the overview at the end of part 1, formed the basis to preliminary research carried out by the author with its implications for the main investigation. This is now treated here as follows:

6.1 Initial Aims and the Pilot Studies

6.1.1 Initial Aims

1) To develop a working basis to the notion of causality for the main investigation, by obtaining information mainly from first year middle school children.

2) To discover what relationships, if any, exist between a S's causal appreciation and his other abilities.

3) To examine question wording, material familiarity, probing and other variables that may effect childrens' causal appreciation.

4) To explore possible areas which may prove suitable for longitudinal study.

6.1.2 The Pilot Studies

With the initial aims acting as guiding principles for the exploratory work to be carried out on causal thinking, two separate pilot studies were completed in the first year of the investigation. The first study was purely exploratory, while the second was mainly confirmatory. Only brief details of the studies will be supplied and discussed in this section, and only those findings that have direct reference to the main investigation will be included.

(A) Experimental Details

The School

Both pilot studies were carried out in the same middle school of a south London Borough having approximately 500 pupils on roll. The school was co-educational, catholic and included children whose parents were mainly of middle class background.

The Sample

This included the first year intake, each child being 9 years of age or more on the 1st of September, the day the new school year began. 40 different Ss (20 males and 20 females) were chosen at random from a list of children for each pilot study.

Experimental Design and Procedures

The main investigation was partly envisaged to be an exploratory study of how first year middle school children appreciate causality. This therefore, influenced the experimental design and procedures adopted for the pilot studies. The design and procedures were based on Piagetian interview methods, which are the main source of data and where the subject acts as his or her own control. As to the design of a proposed longitudinal study, limits on the author's time made it impossible to develop any extensive piloting of this approach. However, during the first year of the investigation two pilot studies were carried out, and areas for research in which small changes in children's causal thinking might take place were noted. Such areas if they existed, could be considered for a longitudinal study.

Both pilot studies were in the main, guided by the initial aims, but in the first pilot study, the author was concerned to use instruments, in some cases fairly established ones to get the feel of children's understanding of causality. This was primarily to meet the first aim. It was thought that by attuning oneself as an E first to a modern view of causality, and then to explore what conception children actually had of the phenomenon, one was establishing a very crucial and fundamental starting point to the study of causal thinking in children.

Instrumentation used in the Pilot Studies

In order to investigate the initial aims in the first pilot study, some of the original tests and procedures of Piaget (1930), Nass (1956), Laurendeau and Pinard (1962), and Berzonsky (1969) were used as well as several tests designed by the author. It became clear from a methodological as well as from as well as from a conceptual point of view, certain features emerged that required further exploration, modification and in some cases confirmation before any proper study into causal thinking could go ahead, and this was the function of the second pilot study. The general findings from the two studies will be pooled together for the purposes of this chapter, and the implications they had for finally designing the main investigation will be subsequently discussed.

(B) General findings of the Pilot Studies and Implications for the Present Investigation

The findings of the Pilot studies are treated descriptively and will appear under the following headings:-

(1) Findings related to a Notional View of Causality, as appreciated by middle school children.

(2) Findings of possible relationships between causal thinking and other abilities.

(3) Findings related to the influence of intervention, or teaching of certain causal situations.

(4) Findings related to methodological considerations arising from the pilot studies.

(1) Findings related to a Notional View of Causality as appreciated by middle school children

The responses given by children to the various question schedules, indicated to the author that many of the children had a multiplex notion of causality. Many responses revealed, that there was an initial and fairly stable view of a causal situation after several probes had been applied. Children were also prone to give extra information, which often revealed indications of a contemporary and more modern view of causality. Most of this extra information manifested itself as causal plurality. It occurred to the author that if children were capable of causal pluralistic appreciation, they might have some idea about causal probability, and ultimately an ability to logically explain why one cause or set of causes was more likely than other cause/s to give the effect in question. Further studies using a more refined instrument designed along these lines, which probed not only initial causal responses but, pluralistic, probabilistic and finally logico-causal response was employed.

In the course of questioning children during the first pilot study, it became obvious that certain situational variables such as probing, material familiarity and sources of familiarity, might influence the responses given by the children. So often did sources of information emerge i.e. "my brother told me", "we did it in school yesterday" etc. that in the second pilot study, specific questions were designed to this end. It was found that this experiential factor seemed to be intimately related to the whole process of causal thinking. For this reason, the final version of the Physical Causality Test Battery (PCTB) had incorporated into it an experiential component. Therefore the major instrument used to explore causal thinking in the middle school child was multiplex in nature comprising of five components :-

(1) initial causal component

(2) pluralistic causal component

(3) probabilistic causal component

(4) logico-causal component

(5) experiential causal component

Other causal instruments were also devised and adopted as additional and comparative measures. These included a demonstrational test i.e. the water level test, causal reasoning tests, a causal problem solving test i.e. electric light problem, bicycle drawing test, a causal creativity test and finally, a language ability test, involving the use of causal connectives. Clearly, many "teething" problems arose in the construction and administration of these tests, and it was during the second pilot study, that most of the problems were sorted out. However as many of these tests were used as additional indicators of causal appreciation, and were fairly straightforward, (some having been tried out by other workers), the findings indicated their suitability as additional comparative measures, and therefore no more will be mentioned at this stage.

(2) Findings of Possible relationships between causal thinking and other abilities

Mention has already been made concerning the batch of causal instruments used in the pilot studies in conjunction with an exploration of a notional view of causality. However, they also need to be mentioned briefly here, as the "raison detre" for including them, was to explore other conceptions of cause, not specifically investigated in the Physical Causality Test Battery (PCTB). The tests try to assess causal appreciation in a practical context, use of causal language, causal problem solving and causal creativity. It occurred to the author during the first pilot study how closely related these other aspects of causal thinking, might be to the main PCTB. The results indeed seem to indicate, that there was a relationship, although not always a clear cut one between these measures. However, it was enough to include them in an improved form for the main investigation.

Non-causal instruments included a relational test, judgemental/verification test, scepticism, conservational notions and a standardised Richmond Achievement test. All were tests that had been used previously by other workers, although the author either modified them or added to them in certain cases. The findings of the second pilot, study showed that relationships existed between the performance of Ss on some of these tests and their performance on the causal instruments. However, in conservational tests little relationship exists. This finding prompted the author, to examine further the view of Piaget with regard to the primacy of operational thinking and that of causal thinking, in the context of transformations etc. Piaget has in fact this to say :-

> "The nature of causality thus always includes a system of transformations that cannot be reduced to a simple relationship of cause and effect pre-supposed by common

> sense. Even in cases where such a relationship seems to exist, as in the example of a push, there intervenes in reality an elementary structure, that is compensations between losses and gains, composition of transformations and conservations etc. not to mention directions - in other words a deductive system".
>
> Piaget (1974) p. 134.

This means that the conservational tests had to be refined and at the same time made more extensive by including volume in which [Lovell et al(1961,1962)] procedures probing both these concepts were adopted, as they present a more rigorous interpretation of the transformation and compensations, Piaget talks about in the above quotation. It was decided to investigate conservation of area and volume, (not included in previous research) as 9 year old children may begin to conserve these notions, possibly giving an indication of a relationship between their appreciation of the causal components, and the ability to conserve at the higher end of the horizontal decalage.

(3) <u>Findings Related to the influence of intervention or teaching of certain causal situations</u>

In selecting the various items for the causality tests, the author was aware that some of them might be part of class activities, and although many of the items chosen were not taught in the period of the pilot studies the "rain" item was. Much has been written of late on the role of teaching and other intervention processes in schools, and more recently in science teaching with special reference to causality (Harlen 1979). However in view of the influence the teaching exposure had on the "origin of rain" item during the pilot study, it was thought that a more detailed and controlled examination could be made of the teaching variable. One particular trend was that children who answered the "rain" item and had been exposed to class activities on rain, tended to give more information about the phenomenon on one hand, but a more confused relational answer on the other. It was therefore decided to explore this educationally important trend further in the main investigation.

(4) Findings related to methodological considerations arising from the pilot studies

Findings related to the above fall into five main sections:

(a) Test content e.g. choice of the test item, materials etc.

(b) Test Presentation e.g. language used, materials, probing frequency.

(c) Categorisation and Scoring of Responses.

(d) Approaches to testing e.g. clinical interviewing vs mass testing etc.

(e) Extraneous factors e.g. testing, teaching variables etc.

(a) Test Content

This is mainly concerned with the choice of item, or apparatus used as the case may be. In the selection of item material for the Physical Causality Test Battery, Berzonsky's Familiar, Remote and Malfunctional categories were adopted, but care was used not to include too many male or female biases on the individual items listed under these categories. In consultation with some of the teachers in the pilot schools, and the results obtained from using certain items which obviously had a built in bias the list as shown in Table No. 7. (in Chapter 8) was eventually used. However, some of the items chosen for the final instrument appeared to have an appeal for boys and girls equally, due to changing attitudes on the part of teachers, parents and the children themselves. Examples of such items seemed to be motor car movement and plant growth etc. in which boys and girls answered along similar lines.

In order to obtain the best conditions for children to respond to causal situations, both the apparatus and verbal content was kept as simple as possible. One of the problems in selecting item materials is related to past experience which the child brings to bear when responding to a question about a causal situation. While some authors notably Schultz and Mendelson (1975), Siegler (1975) have tried to control for past experience by alternatively emphasizing novelty instead, the result has tended to produce an over-complicated apparatus, impeding a clear appreciation of the causal phenomenon under study.

(b) Test Presentation

Three facets of the test presentation will be discussed; i) the question wording with reference to the interrogative; ii) the variety of verbal and non-verbal approaches and iii) the frequency of probing.

i) The question wording. In probing causal notions, previous workers such as Nass (1956), Elitcher (1967), Berzonsky (1969) have raised the use of the interrogative in questioning children about causality and more details of their findings are discussed at length in Chapter 5. However, when using "why", "what" and "how", these workers found that unless the question wording is controlled, children may be inclined to give different responses, to the question probing the same causal situation. Bearing this work in mind, 3 groups of 10 children were questioned, one group with "why" question, another with "how" and another with "what makes". The findings showed only small differences between the 3 groups with "what makes" questions producing more mechanical type answers, and therefore in line with the expected outcomes for 9 + middle school children. In the light of this finding, where possible, all questions probing causality in the main causal instruments used the interrogative "What", followed by "makes". However, in questions probing experiential and logico-causal components in the PCTB, "where" and "which" were used respectively.

ii) Variety in the use of verbal and psycho-motor approaches. In order to obtain as comprehensive a view as possible of causal thinking in the middle school child, emphasis on verbal, demonstrational and child action procedures respectively were tried out. The pilot studies showed different results in the tests that used the same response categories. For example, it appeared that a purely verbal test battery like the PCTB produced a greater number of higher response categories, than did demonstrational procedures as in the Water level test. As this seemed an interesting finding to follow up it was decided to include the water level test in the final investigation. Such comparisons raises fundamental educational issues too, for if a purely verbal test of a notion like causality stimulates a more qualitative explanation than a demonstrational or child action situation for this age range, what are the merits of over-promoting practical scientific enquiry, when in the long run children can provide an acceptable explanation through purely verbal experiences? Parts of the causal reasoning test, the water level test, the electric light problem, the bicycle and causal creativity tests were all selected, and further modified mainly to this end. This was done to establish how different approaches influence children's appreciation of causality and to draw any educational as well as psychological implications from the results.

iii) Frequency of Probing. It was realised after the first pilot study, that the instruments devised by workers like Laurendeau and Pinard, Nass etc. and subsequently used by the author, did not account for the positive effects of repeated probing. Several probes used to confirm or elaborate a first response is a necessary operation in order to get a satisfactory and representative idea of how each child really appreciates a causal situation. The work of Berzonsky on probing is particularly pertinent here. So in the second pilot study, secondary probing was built into many of the tests, but especially the initial causal and the pluralistic component of the PCTB, thus for :-

Initial Causal Component

Probe 1 "What makes a car move?"

is followed by

Probe 2 "Can you tell me more; what is it that makes the petrol or ...... do to get the car moving"

and for the :

Causal Pluralistic Component

Probe 1 "Are there other ways you can think about that makes a car go?"

followed by

Probe 2 "Can you think of others?"

The findings of the 2nd pilot study showed, that by employing at least a second probe for all components, the quality of the responses in many cases improved in terms of extra information. However, more important, a fuller indication of causal explanatory elements including relational and logico-deductive thinking, linking possible causes with an effect or effects was obtained. Therefore, in the final investigation, causal instruments especially parts of the main PCTB have secondary probes built into them as a regular feature.

(c) Categorisation and Scoring of Responses

Perhaps one of the most important aspects of the pilot studies and indeed the main investigation which succeeded them,was the nature of children's responses to causal questions and the problem of categorising them. While Piaget (1930) put forward 17 types of causal explanations, workers like Nass, Laurendeau, Pinard and more recently Berzonsky used fewer categories. While the author explored several guidelines for the categorisation of causal explanations given by the children in the first pilot study, it emerged that Piaget's list of categories did not suit the age range of the sample being studied. Piaget seems to have emphasized pre-causal categories and under-emphasized the details of mechanical and logico-deductive causal explanation. On the other hand, the categories used by Nass, and the other workers were certainly too imprecise for its use in assessing the responses the author obtained from the children questioned in these pilot studies. After careful editing of the tapes, which recorded the responses of children especially in the PCTB it appeared that six types of response consistently appeared. The first two of these include a "don't know" and a non-mechanical response (or non-naturalistic), which roughly embrace all Piaget's pre-causal explanations. However, of more interest were the so called naturalistic responses for this age group, and the way they fell into four further categories. The explanations which figured in the four categories, ranged from one or two word answers, to explanations approaching not only correct informational components but adequate relational and causal explanatory components too.

From the second pilot study, a more refined instrument was produced which included the six categories mentioned above. Response categories were also devised for the other causal instruments and in the water level test and electric light problem, the same categories were used. In scoring the categories, attention was given to the concept of "psychological distance" and the high categories were awarded higher scores and a low category a low score e.g. category 1 explanation was awarded 5 points while the category 4, 1 point. Between categories 2 and 3 there was a gap of 2 points to try to account for some form of psychological distance.

The other tests causal and non-causal alike were either categorised on a +,- and transitional basis e.g. conservational tests, or were scored in line with procedures for standardised tests e.g. Creativity test, Richmond Achievement Battery.

(d) Approaches to Testing

All the tests applied in both pilot studies were on a one-to-one basis and all interviews were tape recorded. Perhaps one of the most important findings relating to the approaches used in the testing, revealed the necessity for contact periods of not more than 35 minutes for any test or batch of tests. Beyond this time both "Subject" and later on, "Experimenter fatigue" can set in. Therefore three separate batches of tests were to be applied on three separate occasions in the main investigation. Two batches would be applied using clinical interview approaches and a third batch given on a mass basis e.g. Richmond Achievement, Bicycle drawing, Creativity tests etc..

(e) Extraneous Factors

Two main extraneous factors emerged during the pilot studies, that might conceivably confound the interpretation of results in a main investigation. Teaching of the test material (this has already received attention earlier in this chapter) and the visits to schools of visitors from the local community and the educational authority e.g. road safety organised by the police. The latter type of visit, actually arose towards the end of the second pilot study in which police officers explained how a bicycle worked, before going on to discussing its operation under traffic conditions. Also, topical events reported in the newspapers, radio and television tended to come into childrens answers, to questions on causal phenomena. The possibility of these factors occurring in the main study were therefore noted, inasmuch that they may affect the result and their interpretation.

(C) Aims and Scope of the Present Investigation

Both the findings of the pilot studies and the review of the pertinent literature which preceded and accompanied them, indicated several lines of enquiry could be followed up in the main investigation. However of these the following were chosen.

1) That the main investigation could explore and establish the nature of causal appreciation in first year middle school children and to examine this in relationship to other abilities.

2) To select aspects of causal appreciation shown by first year middle school children, and examine what changes if any take place over time.

The reasons behind the choice of these two main lines of enquiry are as follows:-

a) Little information exists as to how first year middle school children actually appreciate causality.

b) even less information is available, in the way first year middle school children's ability to explain causal situations relate to other abilities e.g. performance or achievement tests, language ability etc.

c) information obtained from (a) and (b) above, could shed light on how children perform in a crucial area of science education namely, explanation of cause and effect and furthermore, how the parts of a school curriculum may be improved as a result.

d) up until recently, most cognitive developmental studies have been cross-sectional and there has been a cry from several workers for longitudinal studies of cognitive development e.g. Lunzer (1960), and causal thinking in particular Laurendeau and Pinard (1962). The investigation of explanatory patterns over time would not only have validity for cognitive development in general, but may shed light on children's ability to explain scientific, historical, and other subject disciplines in their use of causal analysis.

The two statements above, which refer to the lines of enquiry followed in the main investigation define both the aims and scope of the present study. These therefore are as follows:

Main Aims:

(1) To explore the nature of causal thinking in British middle school children.

(2) To examine what influence factors such as experience, intervention etc. has on causal appreciation.

(3) To establish to what extent first year middle school children exhibit Piagetian stage norms as they relate to causal thinking and operational thinking.

(4) To examine what relationship exists between children's performance on causality tests, and other tests of ability.

(5) To investigate certain aspects of first year middle school childrens' appreciation of causality over a measured period of time.

Scope of the Investigation

The psychological framework chosen as a basis for the investigation is that of Piaget, but the author's own interpretation of the development of causal thinking and its relationship to other abilities is also used. The studies of the first year middle school intake, would form the basis to these studies mentioned above. Most of the causal situations, would draw examples from science, and physical causality in particular receives considerable attention. This is within the author's experience as a science educator, and is in line with the need for research to be carried out into science education in British middle schools.

The investigation examines a first year middle school intake, and follows up some of the causality tests into the second year. Both first year and follow up study would be examined, and if there were any obvious differences between age cohorts, these too would be investigated further, in order to detect any trends that may emerge.

6.2 Guiding Statements, the Research Problems and Hypotheses of the Main Investigation

6.2.1 Introduction

In the light of some of the findings in the research literature discussed in Chapters 3, 4, 5 and the outcome of two pilot studies, it was decided to examine seven research problems related to the appreciation of causality by first year middle school children. The selection of these problems arose for the following reasons:

(1) The recent work examining the relationships between causal notions and other abilities, seems to raise not only interesting, but valid developmental problems e.g. recent work of Piaget, de Garcia (1974) and Berzonsky (1973). Furthermore, this work may be valid not only from a psychological standpoint but from an educational one too. While recent studies have centred around earlier age groups between e.g. 5-6-7 years, few researchers have investigated aspects of causality in detail beyond 8 years of age in Britain the one exception being King, (1960), and even his work was part of a larger study into concept development.

(2) While longitudinal studies of cognitive development are becoming more frequent, there are many areas which have not received much if any attention, and causality is one such area.

(3) From the pilot studies carried out by the author, several lines of research became evident concerning the relationship between causal appreciation and the use of language, creativity and standardised measures.

(4) Perhaps, one of the most crucial areas that has received <u>some</u> measure of attention in former studies has been the nature of children's explanation, and this area particularly seemed to emerge as a fruitful one, for not only a particular age range, but for a longitudinal study of that age range.

(5) Finally, the pilot studies showed that childrens' understanding of causality indicated the notion to be one that consisted of components. Therefore in putting forward the research problems and their contingent hypotheses, not only was this componential nature seen as a promising research area, but an area in which some of the components could be analysed over a time. For more precise details concerning the componential nature of causal

thinking the reader is referred to Chapter 8 on Instrumention. However, for the purpose of what follows in this discussion the five main causal components are briefly described thus:

a) <u>initial causal component</u> - this entails an initial appreciation by children of a causal situation.

b) <u>pluralistic causal component</u> - this provides evidence of the awareness on the part of the child of several causes.

c) <u>probabilistic causal component</u> - this indicates to what extent the child is able to appreciate causal probability in a certain situation.

d) <u>logico-causal component</u> - this indicates the child's ability to logically explain the most likely cause or causal set.

e) <u>experiential causal component</u> - this indicates some of the sources from which children derive their information to explain causal situations.

The Research Problems are grouped under two guiding statements, that reflect the main concerns of this investigation. The first statement, tries to cluster research questions concerned with the establishment at a certain age; of the <u>nature of causal thinking</u> and its <u>relationship</u> to other abilities. The second statement attempts to cluster research questions concerned with a study of <u>patterns of causal thinking</u> over a <u>time</u> period.

<u>Guiding Statement 1</u>

<u>To establish the nature of causalthinking in first year middle school children, and to examine this in relationship to other abilities.</u>

Research Problems Related to Guiding Statement 1

1. How do children in their first year of middle school appreciate various components that make up causal thinking?
2. To what extent do experiential influences, whether they be informal, or formalised through structured school experience influence causal appreciation?
3. How does the appreciation of various components of causal thinking relate to other abilities children have?
4. To what extent do first year middle school children exhibit Piagetian stage norms as far as causal thinking is concerned, and how does this relate to operational thinking?
5. What special features emerge from a study of causal thinking in first year middle school children, that could warrant a longitudinal study.

Guiding Statement 2

To select patterns of Causal thinking exhibited by first year middle school children, and to examine what changes if any, take place over time.

Research Problems Related to Guiding Statement 2

6. How does the quality of causal explanation change over a measured period of time?
7. How does the appreciation of an initial causal component measured by a hierarchical categoric system, compare with standardised measures of achievement as indicators of developmental change, over a certain period of time.

6.2.2 The Hypotheses, with restatement of the Research Problems

Hypotheses Arising From Research Problem 1

Restatement of Research Problem 1

How do children in their first year of middle school appreciate various components that make up causal thinking

Comments

Hypotheses relating to this research problem are directed towards the following processes and variables.

(a) explanatory processes

(b) situational variables, such as nature of stimulus material

(c) verbal, psychomotor and demonstrational modes

(d) additional notions of causality

The Hypotheses

(1) When children explain an initial causal component, their explanation is part of an hierarchical system

(2) That such an hierarchical system is a feature of the mean age of the children investigated in this study

(3) That a hierarchical system of causal explanation is differentially related to the nature of the stimulus material e.g. familiar, remote or malfunctional

(4) That the appreciation of the pluralistic causal component is differentially related to the nature of the stimulus material e.g. familiar, remote or malfunctional

(5) That the appreciation of the probabilistic causal component is differentially related to the nature of the stimulus material be it familiar, remote or malfunctional

(6) That appreciation of the logico-causal component is differentially related to nature of the stimulus material, be it familiar, remote or malfunctional

(7) That appreciation of causal situations, presented in a demonstrational mode, and a purely verbal mode will be related

(8) That appreciation of causal situations eliciting mainly psychomotor responses, and those eliciting purely verbal responses are related

(9) That appreciation of additional notions of causality as measured by causal reasoning and causal problem solving tests, will be related to the appreciation of initial, pluralistic and logico-causal components of causal thinking.

Hypotheses Arising From Research Problem 2

Restatement of Research Problem 2

How do experiential influences whether they be informal, or formalised through structured school experience, influence causal appreciation

Comments

In view of the difficulties that developed during the investigation (see Chapter 11.1.2) controlled experimental procedures had to be abandoned so that the hypotheses that follow are tentative working statements.

The Hypotheses

(10) That informal or incidental experiential influences, are related to the appreciation of the initial, pluralistic and logico-causal causal components

(11) That informal or incidental experiential influences, are related to the nature of the stimulus material used in the appreciation of initial, pluralistic and logico-causal components

(12) That teaching a particular causal situation would influence the explanation of that situation

Hypotheses Arising From Research Problem 3

Restatement of Research Problem 3

How does the appreciation of various components of causal thinking, relate to other abilities children have?

Comments

Hypotheses related to this research problem are directed towards the following variables:

(a) special linguistic ability

(b) relational ability

(c) judgemental/verificational ability

(d) scepticism

(e) creativity

(f) standardised measures of achievement

The Hypotheses

(13) That childrens' appreciation of initial, pluralistic and logico-causal components, is related to children's ability to construct sentences with causal connectives

(14) That children's appreciation of initial, pluralistic and logico-causal components, is related to children's ability to complete sentences with causal connectives

(15) That children's appreciation of initial, pluralistic and logico-causal components, is related to children's relational thinking

(16) That children's appreciation of initial, pluralistic and logico-causal components, is related to children's ability to verify a practical situation

(17) That children's appreciation of initial, pluralistic and logico-causal components, is related to children's creative ability in causal situations

(18) That children's appreciation of initial,pluralistic and logico-causal components is related, to children's performance on standardised achievement tests

Hypotheses Arising from Research Problem 4

Restatement of Research Problem 4

To what extent do first year British middle school children exhibit Piagetian stage norms as far as causal thinking is concerned, and how does this relate to operational thinking

Comments

Hypotheses related to this research problem are directed towards the following processes

(a) the nature of explanation as an indicator of what stage a child has reached, and the status of the explanation in that stage

(b) examination of the problem in the light of the level of the child's operational thinking, vis-a-vis initial causal components

(c) examination of the problem in the light of child's operational thinking, vis-a-vis logico-causal components

The Hypotheses

(19) That appreciation of initial causal components are related to Piagetian norms for causal appreciation, and for this age range.

(20) That appreciation of initial causal components, is related to operational thinking as expressed in children's performance on conservational notions such as that of substance, weight, area and volume

(21) That appreciation of logico-causal components, is related to operational thinking as expressed in children's performance on conservational notions, such as conservation of substance, weight, area and volume

Restatement of Research Problem 5

What special features emerge from a study on causal thinking in middle school children in their first year that could warrant a longitudinal study?

Many features emerged and some of these form the basis to research questions 6 and 7.

Comments

Two major considerations were borne in mind in selecting the succeeding research questions and the hypotheses generated by them.

(a) the fact that certain response patterns emerged during the first part of the study of causal thinking, after all the first year intake of children had been interviewed. These response patterns concerned the nature of causal explanation and prompted the writer to examine in depth how these patterns changed or not, over time

(b) how such changes compared with children's performance on standardised measures of achievement

As will be seen from the results of the first part of this investigation, many interesting relationships were found to exist between the various measures of causal appreciation and other abilities. It is beyond the scope of the present investigation, to follow up all these relationships along a longitudinal continuum for reasons of time and non-availability of the research personnel.

Research Problems 6 and 7 are in the context of a longitudinal design. Such designs in developmental psychology, aim to discover small changes in individuals and/or groups of individuals which can give us a more informed picture of what is happening in children's understanding of a particular notion; which in this case is causality.

Research Problems Related to Guiding Statement 2

Restatement of Research Problem 6

How does the quality of causal explanation change over a measured period of time?

Hypotheses arising from Research Problem 6

(22) That children's explanation of an initial causal component as measured by a hierarchical categoric system, changes over time in an upward direction

(23) That children's explanation of an initial causal component, as measured by a hierarchical categoric system, changes over time and is a function of the nature of the stimulus material, be it of a familiar, remote or malfunctional level of experience.

Restatement of Research Problem 7

How does the appreciation of an initial causal component measured by a hierarchical categoric system compare with standardised measures of achievement as indicators of developmental change over a certain period of time?

NB: No hypotheses accompany this research problem, as the author was interested in a general comparison between the qualitative analysis of developmental change and an analysis, employing quantitative measures.

CHAPTER 7

THE SAMPLE, EXPERIMENTAL PROCEDURES AND RESEARCH DESIGNS

CHAPTER 7

THE SAMPLE, EXPERIMENTAL PROCEDURES AND RESEARCH DESIGNS

This chapter is divided into three main sections these are :-

7.1 The Sample

7.2 Experimental Procedures

7.3 The Research Designs

7.1 The Sample

(a) Method and Criteria for Selection

The children used in this study attended a middle school in an outer London Borough. On advice given by the inspectorate for this borough the school selected was chosen on the following grounds:-

(i) that in company with one other middle school in the borough this school was non-denominational;

(ii) that children entering this particular middle school in their first year give a distribution of reading scores which indicated an average middle school population for the borough (see Table No. 2);

(iii) that the school had been the only one left out of five middle schools that had not been used for an extended research project;

Therefore the sample school is non-denominational, has children having a fairly normal distribution of reading scores and had not been used previously for any large scale research activity.

(b) Educational Background

In 1968 the borough had embarked upon a three tier comprehensive school system catering for the following ages:

First Schools	-	5 - 9 years
Middle Schools	-	9 - 13 years
High Schools	-	13 - 18 years

Three main and five other feeder first schools sent children to the middle school used in this study. All children entering the middle school from the feeder schools had a reading test before leaving their first schools the results of these tests are in Table No. 2.

Table No.2 Showing Results for First Year Intake on the NFER Reading Test 9+ BB- Standard Scores (N = 125*)

Mean	93.276
S.D	11.807
Minimum Score	70
Maximum Score	127
Variance	139.414

* Scores were only available for this number of Ss

(c) Environment of the School

The school stands in a South London suburb with a considerable amount of light industry surrounding it. The housing is a mixture of Council houses, flats and private semi-detached residences and from which most of the children attending the school came. There were several parks and commons in the vicinity of the school.

(d) Parental Status and other socio-Economic Factors

The socio-economic status of the childrens' parents studied in this investigation is shown in Table No.3. From this table it can be seer that most parents worked in semi-skilled, manual occupations with a sprinkling in professional and business occupations. The 5 categories appearing in Table No.3 reflect the categories used by the Registrar General.

Table No.3 Showing Details of the S.E.S. Categories for the First Year Intake (N = 135*)

S.E.S Category	Absolute Frequency	% Frequency
1	5	4
2	16	12
3	65	48
4	34	25
5	12	9
N.I	3	2
Totals	135	100

* Apart from minor variations the % distribution of categories was the same for both the experimental samples. (see N, Table No.2).

(e) Ethnic and Cultural Nature of the Sample

About 15% of the sample tested were of West Indian, Indian and South European origin. However, as ethnic and cultural factors were not being studied in this investigation, no further records were made of this 15%.

(f) School Organisation and Curriculum

The school numbered just over 500 children on roll and these were divided into 4 year groups. This investigation took into consideration the first year intake from September 1976 until they had reached the end of their second year in July 1978. The first year intake in September 1976 was divided into five classes by the headmaster so that each class was of mixed ability. In their second year the children were divided amongst four classes and this distribution was also based on a mixed ability grouping.

As this investigation is concerned to some extent with science education, mention will be made very briefly of the way science was taught and organised in the school.

Science was approached in a very practical manner in both first and second years, being treated in the main as an integrated study. It had been arranged with the year leaders and head of science that one topic i.e. rain cycle be taught at intervals to coincide with this investigation and as will be shown and discussed in subsequent chapters where this did take place, certain effects were recorded and must be taken into account in interpreting the results. Most science teaching was carried out by a specialist teacher in either first or second years.

All children were assessed once each year by the application of a Richmond test. The details of this test are discussed in Chapters 8 and 9 respectively and the childrens' results are included in Appendix H, therefore no more details will be given here.

(g) The Numbers Tested and Interview Selection Procedure

135 children were admitted in September 1976 making up the first year intake.

In the first batch of tests* all 135 children were tested. However due to several limitations, e.g. shortage of time, attrition during subsequent testings, non-availability of children at the testing times etc. this number of 135 was reduced to 102 children for the first part of the study** while for the longitudinal design, the final numbers of Ss tested, Experimental and Control together was 112.

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* see page 163

** see Research Design page 168

(h) Sex

Of the 102 children tested the number of boys was 50 and the girls 52.

In the longitudinal design where 112 children were tested, the numbers of boys and girls were equal.

(i) Age

All children admitted to any middle school in the Borough have to be 9 years old on the 1st September. Therefore all the children were 9 plus as they entered their first year at the middle school. Table No.4 shows the age distribution in months together with means, standard deviations etc. for the total intake. Of that intake values for the 102 Ss tested in the first year and 112 Ss tested longitudinally are also included.

Table No. 4 Showing Age Details for the total First Year Intake and Experimental Samples

Samples	Mean	S.D.	Min.	Max.
Total Intake (N = 135)	115.103	3.084	108	122
First Year Study (N = 102)	115.186	3.452	108	122
Longitudinal Study (N = 112)	115.142	3.429	108	122

7.2 EXPERIMENTAL PROCEDURES

(a) Setting

Apart from the Bicycle Drawing, Creativity and Richmond Tests, which were administered on a class basis, the remainder were given individually by the author who was the E at all times.

A room in the school was set aside for the interview to take place. The room contained a small table, two chairs, one for E, the other for the S. A small table was placed adjacent to the main table to hold the apparatus for the various tests. The room had an electrical socket into which was plugged a tape recorder. Most of the individual testing was recorded verbatim on recording sheets* and on tape.

After each set of interviews the verbatim version was checked with the tape recording for purposes of accuracy and reliability. A set of 20 tapes randomly selected were given to a trained psychologist in order to provide some check on the reliability of the data. It was not possible to extend this reliability procedure for reasons of time, cost, and non availability of qualified personnel.

(b) Preliminaries to Test Administration

All Ss were introduced to the author by the year leader at the start of the investigation in September 1976. The Ss were told the E would be meeting them individually several times during their first and second years as the E was interested to find out how they learnt about certain things. What they would tell the E might help him to find out more about how they learned.

When each S came to be interviewed individually, questions were asked concerning age, family size and parental occupations, S's interests and hobbies etc. the responses being entered on a recording sheet. The S was told that he or she would now be asked more questions, they were to think hard before answering them, that there were no 'right' or 'wrong' answers and that if they did not know the answer to say "I don't know".

Each S sat opposite E and was at a comfortable eye level. The

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* See Appendix C.

tape recorder was placed on the table and no attempt by E was made to hide it. The various materials and apparatus as well as recording sheets were stored on an adjacent table.

(c) Sequence of Test Instruments

Reasons for the sequencing of tests were as follows:

(i) verbal tests were alternated where possible with non-verbal and demonstration type tests in order to vary the activity and keep the S interested and alert.

(ii) because of the number of tests to be applied to each subject it was thought that the whole testing procedure as far as the individually administered tests were concerned, be given in two batches, the second batch extending over a longer period of time as more tests were included in this batch.

(iii) with the longitudinal design in mind the Verbal Test for Physical Causality was presented first as this was likely to be the most important.

(iv) the causal reasoning, scepticism and relational tests were presented in the second batch on the basis that Ss would have settled down to the testing situation in their new school by the second term, during which the second batch would be administered.

(d) Contact Time With Ss

Ss on average took 35 minutes to answer three tests and the introductory questionnaire in Batch A, while Batch B took on average 45 minutes and included five tests.

Below is a list of the tests given in the two batches:

Batch A*

1. Physical Causality Test Battery (PCTB)
2. Language Test on Causal Connectives
3. Causal Demonstration - Water Level Test

Batch B*

4. Conservational Tests for Notions of Substance, Weight, Area and Volume
5. Scepticism Test
6. Judgemental/Verification Test
7. Causal Reasoning Tests
8. Relational Test
9. Causal Problem Solving Test - electric light

Batch C*

10. Creativity Tests
11. Bicycle Drawing Test
12. Richmond Achievement Tests

Batch C tests were administered on a class basis which lasted approximately 30 minutes in the case of Creativity and Bicycle Drawing Tests and 1½ hours for the Richmond Test.

It was decided to divide up the contact time between Batch A and B on the basis that eighty minutes at one sitting total time for the batches would be too taxing for the S.

In the longitudinal study only the Physical Causality Test was applied to the experimental group on the second and third occasions. The contact time for these testings was on average 20 minutes per S.

(e) Questioning Techniques and E-S Rapport

From the findings of the pilot study together with the work by Nass, Elitcher and Berzonsky most questions probing causal explanations would begin with the interrogative "What" coupled where appropriate to "makes". The use of "which" and "where" also appear in questions

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* Further details of these tests will be found in Chapter 8 and Appendices A and B.

probing causal explanation, e.g. where is used in probing experiential aspects, which is used to explore probabilistic causal responses etc. Only when Ss showed a reluctance or hesitation to respond did the E deviate somewhat from the written questions, in order that the rapport did not break down.

(f) Comments on the Two Year Period of Testing

i) Attrition of the original sample numbers equalled 13% for the longitudinal study. This is a relatively small rate over two years, (although not as good as for Versey's study (1974), which was 7%.) This may be partly due to the fact, that the school used here is situated in a reasonably pleasant area and that employment at the time of testing was getting more difficult. However, the most important factor could well have been the stringent national economic factors which ensued between 1976 and 1977; which in turn affected house prices. This gave very little opportunity for families to move in and out of the area, which meant that the captive sample was also a fairly stable one.

ii) By the time the second batch of tests had been administered to 4 of the 5 classes in the first year intake, due to several disruptions in the school timetable, only the first batch of tests were administered to the remaining 5th class. This ensured, that the Physical Causality instrument was tested on all the first year intake, and could be continued as the main instrument for the longitudinal part of the study.

iii) There were several staff changes during the investigation, especially in the first year; these staff either left at the end of a term or at the end of the academic year. However, the position concerning science teachers who taught the children investigated in the sample over the two year testing period remained fairly stable.

iv) On several occasions, staff who taught the children investigated by E, were consulted for information concerning disability, any serious medical history and occasionally, learning problems. These teachers and other interested staff were present at several report back sessions, given by E at certain periods in the investigation. Comments made on these occasions by the teachers were found to be helpful and some of their advice appears in the discussion of results in Chapters 9 and 10.

v) Apart from some timetable changes in the first year, "end of term" functions and medicals, E met little in the way of disruption in gathering the data for the study.

7.3 THE RESEARCH DESIGNS

The present investigation addresses itself to two main research problems, each in turn determining the construction of two main research designs. These designs will be referred to as Research Design A and Research Design B.

(a) Research Design A

Design A is such, that it enables one to explore, and then investigate further the nature of causal appreciation shown by first year middle school children, and what relationship this causal appreciation has with other abilities.

Design A constitutes the base for collecting data of childrens' abilities across the various tests during their first 6 months in the school. A scheme of the design is shown in Figure No.3. page 158.

(b) Research Design B

Design B is such that it enables one to investigate what changes take place in children in the first and second years of middle schooling, and their appreciation of causality over a measured period of time. Figure Nos. 4 and 5, show the scheme of the longitudinal design for combined and separate cohorts respectively. The total number of 112 Ss is made up of the 102 Ss tested in the first year study plus 10 Ss, all of which were given treatments X_1 and X_{12}* on the first occasion. The discrepancy between 112 and the original 135 subjects is due to general attrition, removal, or refusal of Ss, absences during the first part of the study.

(c) Dates and Duration of Treatments - Table No.5 below shows the dates and duration of experimental treatments for Design A.

Table No.5 Showing Dates and Duration of Experimental Batch Treatments for Research Design A

Name of Study	Batch Treatments	Dates	Duration in Days
	A	Sept 1976) Dec. 1976)	43
Study of first year Middle school children	B	Jan. 1977) March 1977)	45
	C	Feb) March 1977)	5

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* See Key in Figure No.4 page 160.

Table No.6 Showing Dates and Duration of Experimental Treatments for Research Design B_1 and B_2

Name of Study	Treatment*	Dates	Duration in Days
Longitudinal			
Study of first	X_1	Sept 1976)	14
year		Dec 1976)	
Middle School			
Children and their	X_{12}	Feb 1977	3
subsequent second			
year	X_1	June-July 1977	10
	X_1	Jan-March 1978	15
	X_{13}	Feb 1978	3

(d) Comments on Research Design A

Research Design A, follows a fairly established pattern for researching Piagetian 'concepts' in that :

i) the design fits the exploratory nature of the investigation;

ii) that the Ss themselves acted as their own controls;

iii) that most of the testing was on a one to one basis.

The sequence of the treatments follow the pattern as shown in Figure No.3 page 158.

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* See Key in Figure Nos. 4 and 5. pages 160, 161.

Figure No.3

Scheme for Research Design A-Study of first year Middle School Children

N	SEX	EXPERIMENTAL SEQUENCE Batch A	Batch B	Batch C
		X_1 X_2 X_3	X_4 X_5 X_6 X_7 X_8 X_9	X_{10} X_{11} X_{12}
102 Ss	52 Boys	✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓
	50 Girls	✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓

KEY:

X_1 = Physical Causality Test Battery

X_2 = Language Test (Causal Connectives)

X_3 = Causal Demonstration - Water level test

X_4 = Conservational Notions — Substance, Weight, Area, Volume

X_5 = Relational Test

X_6 = Judgemental/Verification Test

X_7 = Scepticism Test

X_8 = Causal Reasoning Test

X_9 = Causal Problem Solving

X_{10} = Creativity Tests (Causal Elements only)

X_{11} = Bicycle Drawing Test

X_{12} = Richmond Achievement Test

✓ = Treatment applied

(e) Comments on Research Design B - Longitudinal Study First to Second Year Middle School Children

This design is divided into B_1 and B_2. B_1 design relates to the whole 112 Ss as combined cohorts, whereas B_2 design divides the 112 Ss into cohort A and B. Cohort A contains all the Ss having an age between 108 - 116 months, from the period of the first application of the Physical Causality Test. Cohort B contains all the Ss having an age between 117 - 122 months from the first application of the Physical Causality Test Battery.

(f) The Selection and Frequency of Treatments

As this part of the investigation was concerned with the quality of causal thinking over time, only treatments that are specifically related to this were considered for the design. The Physical Causality Test Battery was eventually chosen out of the other test instruments, measuring causal thinking; for the following reasons:

i) It was a group or battery type test containing several components, related to causal appreciation which could conceivably register interesting change over time.

ii) The componential nature of causal thinking, as it emerged in the study of the children in their first year, appeared to be an interesting area for a follow-up study, and to compare with standardised measures of ability, also administered on a longitudinal basis.

iii) The categories of explanation for the initial causal components, seemed to offer interesting qualitative measures for study along longitudinal lines. In other words, there was potential for monitoring small changes over time in individuals and small groups, an important consideration for any longitudinal study and one which is clearly under-researched, see Versey (1974).

Figure No. 4 Scheme for Research Design B_1 Longitudinal Study of First to Second Year Middle School Children (Combined Cohorts)

N	SEX	STATUS	TESTINGS* AND TREATMENTS 1st	2nd	3rd
		40 Ss (E)	X_1 and X_{12}	X_1	X_1 and X_{13}
	56 Ss Boys				
		16 Ss (C)	X_1 and X_{12}		X_1 and X_{13}
112 Ss					
		16 Ss (C)	X_1 and X_{12}		X_1 and X_{13}
	56 Ss Girls				
		40 Ss (E)	X_1 and X_{12}	X_1	X_1 and X_{13}

KEY: E: Experimental Group Status

C: Control " "

Treatment X_1: Physical Causality Test Battery (PBCTB)

" X_{12}: Richmond Achievement Test (for 9-10 yrs)

" X_{13}: " " " (for 10-11 yrs)

* Approximately Seven months elapsed between testing 1 and 2 and between testing 2 and 3.

Figure No.5 Scheme for Research Design B_2 Longitudinal Study of First to Second Year Middle School Children (Separate Cohorts)

N	COHORT	STATUS	SEX	TESTINGS* AND TREATMENTS 1st		2nd	3rd	
112 Ss	Cohort A 60 Ss	E - 40 Ss	Girls 20 Ss	X_1	X_{12}	X_1	X_1	X_{13}
			Boys 20 Ss	X_1	X_{12}	X_1	X_1	X_{13}
		C - 20 Ss	Boys 10 Ss	X_1	X_{12}		X_1	X_{13}
			Girls 10 Ss	X_1	X_{12}		X_1	X_{13}
	Cohort B 52 Ss	E - 40 Ss	Girls 20 Ss	X_1	X_{12}	X_1	X_1	X_{13}
			Boys 20 Ss	X_1	X_{12}	X_1	X_1	X_{13}
		C - 12 Ss	Girls 6 Ss	X_1	X_{12}		X_1	X_{13}
			Boys 6 Ss	X_1	X_{12}		X_1	X_{13}

KEY: Cohort A = include Ss aged between 108 - 116 months
B = " " " " 117 - 122 "

E = Experimental Group Status
C = Control " "

Treatment X_1 = Physical Causality Test Battery (PCTB)
" X_{12} = Richmond Achievement Test (9 - 10 yrs)
" X_{13} = " " " (10 - 11 ")

* As in the case of Design B_1 approximately seven monthly intervals elapsed between Testing 1 and 2 and Testing 2 and 3

iv) Some aspects of this Battery, indicated its potential for a longitudinal investigation, especially the initial causal component which had been researched by E previously in the pilot studies, although in a somewhat different form.

The original plan for the longitudinal research was to include four testings involving several more experimental treatments. However, due to time constraints on E and the need to complete the study in a certain limit of time, only three testings were made, the interval being approximately 7 months between each.

(g) The Use of Controls

As stated in Chapter 5 practice effects are among the main confounding variables entering into a study along longitudinal lines which has small intervals of time between testings. In order to control for this practice effect, it was decided to select at random from the 112 Ss after the first testing, equal numbers of males and females to act as controls. The number of Ss selected totalled 32. These 32 Ss as Figure Nos. 4 and 5 show, were tested twice over a fourteen month span, and follows a similar method of control selection used by Freyberg (1966). The % number of controls taken from the main sample of 112 equalled 29% i.e. over a quarter of the sample investigated. This figure is somewhat high, when compared with a study such as that of Versey (1974), but it was felt, that by having this number of control subjects a truer picture of the pattern of practice effects would emerge.

It was decided to employ this method of selecting controls and not the one advocated by Schaie (1965) and operationalised and extended later by Versey (1974) for the following reason:

To establish developmentally any comparison vis-a-vis practice factors, it would seem that where you have more than two testings e.g. 3 or 4, it would be important to know the first and last status for control groups. This, in a comparison with those Ss that had experienced all testings, would give a more valid picture as to what had happened in the intervening period, where the practice effect is most likely to emerge. A single testing taken from different samples of a cohort, and tested only once for a particular number of subjects, tells us less about the comparative status for that number of subjects. It also gives an incomplete picture to the knowledge of how practice is affecting the developmental trend. It is therefore, because of this that a first and last status control design was employed here.

CHAPTER 8

THE INSTRUMENTATION

CHAPTER 8

THE INSTRUMENTATION

INTRODUCTION

Instrumentation used in this study will be discussed under two headings. Those instruments devised specifically to measure apprecia- tion of causal phenomena; and instruments devised or adapted to measure abilities other than causal ones. The sequencing, selection and combination of instruments have been already mentioned in Chapter 7. In this chapter, details of these instruments will be described and discussed in the context of their role in the two main designs.

Each instrument that was used in the investigation will be described, as follows; the rationale for its use, and nature of the instrument. The method of recording responses, their categorisation and the scoring will also be mentioned, but any information or details that are tangential to the immediate discussion on instrumentation, but necessary to be included in the thesis e.g. specimen recording sheets, diagrams and drawings are included in Appendices. Finally, a note on the validity of each test will be made.

With description of the instruments, comments of a background and sometimes critical nature will be included. Also, points raised in Chapter 5 on methodological aspects will be elaborated on where necessary, as well as reference to further pertinent literature not mentioned in the earlier chapters.

Classification of the measuring instruments

8.1 Instrumentation for specifically measuring appreciation of causal situations

(1) Physical Causality Test Battery (PCTB)

(2) Causal demonstration - Water Level Test

(3) Causal Reasoning Tests

(4) Causal Problem Solving Test - Electric Light Problem

(5) Bicycle Drawing Test

(6) A Creativity Measures of Causal Appreciation

(7) Use of Causal Connectives Test

8.2 Instrumentation for measuring abilities other than causal, but which may be related to appreciation of causal situations

(1) Relational Test

(2) Judgemental/ Verification Test

(3) Scepticism Test

(4) Conservational Tests - Substance
Weight
Area
Volume

(5) Richmond Achievement Tests

Description and Discussion of Measuring Instruments

8.1 Instrumentation for specifically measuring appreciation of Causal Situations

8.1.1 The Physical Causality Test Battery (PCTB)

This test is a purely verbal one and is used in both the first year study and the longitudinal extension of it. Therefore it will be described and discussed at length.

(a) Nature and Background of the Test Battery

i) Rationale of the Test

The rationale for applying this test was to investigate how children were able to appreciate several aspects of physical causality. From the pilot studies, it became evident that children saw causal situations in a number of ways, and together with the writer's early observations in the run-up to this investigation it appears that causal thinking might be a componential process. This componential process contained at least five elements and probably more. However, only five will be explored in this battery. The scientific and philosophical basis to the author's conception of causality is the one discussed in Chapter 2 and this conception of causality is reflected in what follows:

ii) The Initial Causal Component

This indicates how children, in this case first year middle school pupils appreciate the way a causal situation can be explained, when initial probe or probes are applied. This the author has termed the initial causal component. Initial, as it is the first step in which a child is presented with a stimulus probing or initiating a process of thinking, and its subsequent explanation being directed to a causal situation. Causal, as it relates directly to a condition of causality. Component, as it seems to be separate enough to warrant a form of conceptual compartmentalisation, yet not entirely isolated, so that it does not fit into a relational context with the other causal components.

iii) The Pluralistic Causal Component

Invariably, but not always causal conditions are multiplex i.e. there are several causes to either some effects or to an effect. In probing childrens' thinking in the early stages of this investigation such a component was evident from their responses. However, when children appreciate the state of causal plurality when it exists, and then the understanding of what is involved, a wider view of causal appreciation by children emerges as will be discussed in Chapter 9. As this study was concerned with 9 plus children, it was not possible to probe the nature and occurrence of an appreciation of causal plurality before this age. However, it was found from pilot studies in the investigation of this age range, that not only were children able to detect causal plurality but in many cases had some an understanding of it.

The coining of this component is obvious in that pluralistic conveys the multi-causal nature of the process, while the other terms have been explained already for the initial component. However it should be added that the separateness of plurality as a component is much less so than the initial causal component in that it begs relational questions.

iv) Probabilistic Causal Component

This follows on naturally from the former component and as the term suggests indicates a probabilistic element in causal processes. If there are several causes to an effect, what is the probability that one or a group of causes may be more likely to produce the effect? The apprecia-tion of probability as a process, is what is at the heart of this component vis-a-vis causal conditions. The words making up this component are self explanatory, and again the nature of the component is nearer to the pluralistic one in its separateness as a component in childrens' causal thinking.

v) Logico-Causal Component

Once children recognise a probabilistic causal condition, the next step conceptually would be to give a reasoned explanation of the most likely cause or causal set. This is perhaps the area of causal thinking that may be considered to be an intellectual peak. That is, if a causal condition can be initially explained, considered further in the light of plurality followed by probabilistic processes of thought, the end result should be some logical analysis of the causal condition under question.

vi) Experiential Causal Component

An important aspect of any developmental study is to estimate as far and as thoroughly as possible, the role experience plays in the development of mental structures. (See Chapter 5 pages 107- for a fuller discussion of this area). In monitoring children's appreciation of causal situations during the pilot studies, it was found that the experiential component is important in tracing some of the indicators that may influence causal thinking, and is therefore the least separate of them all.

This component is one that can supply valuable information about the source of initial causal explanation, the possible alternative explanations and reasons for choosing the cause or causal set. Again the terms in the title are self explanatory.

Summarising, the initial causal component represents an initial causal appreciative process while the pluralistic, probabilistic, logico-causal and experiential components represents causal analytical processes but all of which constitute a totality of causal thinking.

b) Structure of the Test Battery

The test battery consists of 18 stimulus items, the 18 are first sub-divided into 3 groups of 6 items, one group consists of items with a familiar level of experience, a second group has items of a remote experience level and a third group having items in which causal situations are of a malfunctional experience level (see Table No. 7). These three levels of experience were used by Berzonsky (1969), which he in turn developed from work by Nass (1956, 1964), on familiar and remote material. The items making up the three levels of experience were alternated in the order, familiar, remote and malfunctional. This was done to attempt some form of modified "scrambling". From Table No. 7, it can be seen that many of the stimulus items have been used by previous workers, and it was thought by the author that not only are such items suitable irrespective of sex differences, but that they gave fairly well tried examples of causal situations. Causal situations which were within the experience and possible comprehension of the first year middle school pupil. Another more important reason for including these items, was that they offered a reasonable spectrum of causal difficulty; were furthermore, of different types of causality e.g. mechanical in the case of cars and television, living processes in terms of plant growth and human death and physical phenomena as in floating and sinking etc. Because of the now familiar television set in most homes, and the current interest in space through factual or fictional experience, these too were included in the list. Each stimulus item was set within the context of 7 probes.

The seven probes are related to the five causal components mentioned earlier.

The first set of probes (1 and 1a) aimed to establish the nature of a child's appreciation of the initial causal component.

The second set of probes (2 and 2a) aimed to establish the nature of a child's appreciation of the pluralistic causal component.

Table No. 7 Showing Stimulus items and levels of Experience used in the Physical Causality Test Battery

	Level of Experience		
	Familiar	Remote	Malfunctional
ITEMS	Car moving	Clouds moving	Clock Stopping
	Boats floating	Origin of Lightning	Glass Breaking
	Birds flying	Space Ship moving	Train Crashing
	Origin of TV Picture	Origin of Dreams	People Dying
	Bicycle movement	Origin of Night	Boat Sinking
	Plants growing	Origin of Rain	Balloon Bursting

Probe 3 aimed to establish whether the child had any ideas about the probabilistic causal component.

Probe 4 aimed to establish whether the child could explain the nature of the probability through logico-causal reasoning.

Probe 5 aimed to establish the experiential component nature which lay behind the child's answers to probes 1 - 4.

As examples of stimulus items put in the context of the 7 probes three items are taken from the test, namely: car movement, cloud movement and clocks stopping. The remainder of the questions relating to the stimulus items are to be found in Appendix A_1.

Example of a Familiar Stimulus Item

1. What makes a motor car go?

1a. Can you tell me more, what makes ....* do that?

2. Are there other ways which you can think about, that could also make a car go?

2a. Can you think of any other ways?

3. Which of the ways you have said is most likely to make a motor car go?

3a. What makes you say that one?

4. Where did you find this out about ways a car can go?

Example of a Remote Stimulus Item

5. What makes a cloud move?

5a. Can you tell me more, what makes ....* move a cloud?

6. Are there other ways which you can think about that could make a cloud move?

6a. Can you think of other ways?

7. Which of the ways you have said is the most likely one to make a cloud move?

7a. What makes you say that one?

8. Where did you find this out about the movement of clouds?

Example of a Malfunctional Stimulus Item

9. What makes a clock stop?

9a. Can you tell me more, what does ....* do to stop the clock?

* Here would be inserted words like "petrol" in the case of car movement or "wind" in the case of cloud movement or "falling" in the case of a clock stopping respectively, preceded by the definite or indefinite article where appropriate.

10. Are there other ways which you can think of that could make a clock stop?

10a. Can you think of other ways?

11. Which of the ways you have said is the most likely to make a clock stop?

11a. What makes you say that one?

12. Where did you find this out about the stopping of clocks?

The use of the interrogative "what" coupled with the verb "makes", was chosen to probe the various components wherever syntactically feasible. The results of the pilot studies had shown, that interrogatives such as "How" and "Why" tended to produce more non-naturalistic responses, while "What makes" statements gave more naturalistic responses. This finding is in line with the work of Elitcher (1967), and follows that of Berzonsky's (1969) whose studies also used this type of questioning procedure.

Before applying the test, each child was told that there were no right or wrong answers but that he or she was to think hard before answering. If he or she did not know about the causal situation they should say "I don't know".

On most occasions the questioning pattern was followed as set out in Appendix A_1. However as all experienced clinical interviewers know, such a method of individual testing can sometimes require deviation from the questioning schedule. In order to maintain a workable rapport, this indeed happened, but only in few cases and generally speaking there was not a marked deviation.

c) Categorisation and scoring of responses for the PCTB

i) Categorisation and Scoring of Responses to the Initial Causal component

Two broad categories were used based on the previous work of Piaget (1930), Nass (1956) and slightly modified later on by Berzonsky (1969) for their interpretation of causal appreciation.

The categories are:

Naturalistic - including mechanical, logical and deductive type explanations.

Non-Naturalistic - including phenomenistic, magical, dynamic explanations etc.

As the author was interested in change in causal explanation, and small changes in particular, it was found during the pilot study that the broad category Naturalistic, while being a useful "global category" did not reflect the subtle differences in the way children attempted to explain causal conditions. The same was also true but to a lesser extent for the Non-naturalistic response category, but limits on time prevented a further study of the responses. The predicted results for causal appreciation could be accounted for by using these global categories, however it seemed to the author these categories did not give sufficient room for prediction of possible behavioural change in causal explanation. That further behavioural change was possible has been discussed in Chapter 6 describing the pilot studies. From these pilot studies, it became apparent that children were capable of responding in a naturalistic way along several levels and which appeared to be hierarchical. Furthermore, there could be several determinants related to these hierarchical levels e.g. frequency of probing, nature of stimulus material, experiential factors, the knowledge base, related abilities such as general aptitude and finally the teaching of the stimulus material in class. After the careful editing of childrens' responses, it seemed that naturalistic responses could be further divided into four categories. The criteria for this categorisation are as follows:

(a) The factual element or knowledge base.

(b) The relational element linking the words and phrases.

(c) The deductive - logical element, putting (a) and (b) into some form of logical context.

(d) The causal element putting (a), (b) and (c) into a logico-causal context.

To give an example of each level of explanation, the responses to the question What makes a motor go? will be given, together with further explanation of the criteria.

Category Naturalistic 4, or N_4 in abbreviated form

Here were included responses having single or two word responses, which give an indication of the naturalistic nature of the response category, but little else e.g. if the answer to the question was petrol it showed that the respondent was operating at the naturalistic level but was not expressing the relationship of the petrol to the movement of the car. In other words criterion (a) was present and only partly as just one word was supplied.

Category Naturalistic 3, or N_3 in abbreviated form

Here responses included several words showing some evidence of relational thinking indicating an attempt at causal explanation. Taking the same example of the car, an N_3 type response could contain the following form :-

petrol and the carburettor, with the accelerator and pedal

or

petrol, battery and carburettor all together

An N_3 type explanation is one that has more factual knowledge and the occurrence of "link-words" e.g. "together", "with", "all" so indicating an higher grade causal explanation from N_4. In other words criteria (a) and (b) are met, but lacking the presence of criteria (c) and (d). However, this type of explanation is relationally weak and only embryonic, as far as expressing causal relationships are concerned.

Naturalistic Category 2, or N_2 in abbreviated form

An explanation classified under this category would contain the key facts but not all of them, it would show fairly clear evidence of relationship/s between the key facts so giving an acceptably correct logical and valid causal explanation. Here criteria (a) and (b) are well satisfied while (c) and (d) emerge as characteristic features in the explanation.

An N_2 type explanation would be as follows:

"The driver turns the key which makes the electricity go from the battery, then the petrol goes through the carburéttor and this gets the engine to go".

Some Ss may add to the above that:

"the petrol gives power to the engine to turn the wheels".

Naturalistic Category 1, or N_1 in abbreviated form

This category explanation would include all the correct and necessary facts or terms, indicating the appropriate relationships between them, all directed specifically towards the explanation of causality. In other words an explanation satisfying criteria (a), (b), (c) and (d).

An N_1 answer would run as follows:

"The driver turns the ignition key which sends the electricity from the battery, to run the starting motor which gets the big engine going. Petrol, then feeds through the carburettor and enters the cylinders. This is ignited by the sparking plug which pushes a crankshaft, linked to a driveshaft which in turn gets the rear wheels to go, so causing the car to move".

Appendix A_2 contains the typical responses in the form of a Response Guide for the four categories of explanation for all 18 stimulus items. These typical responses, guided the author in editing the tapes after each interviewing session. Categorisation of childrens responses is perhaps one of the most difficult problems this investigation has had to deal with. The author however is not alone in this difficulty as the work of Piaget (1930), Mogar (1960), Peel (1965) and more recently Biggs (1980) have shown. Providing some form of scientifically acceptable measure, which at the same time reflects the qualitative response of children at any age raises several fundamental psychological problems. It raises problems related to measurement, it raises problems relating to the interplay between competence and performance, which in turn highlights the difficulty of developmental norms and learning experiences, furthermore the issue of "psychological distance" and its measurement is raised. These issues and problems will be mentioned later on in the thesis, however it needs to be stated at this juncture, that in order to develop some form of categorical system to measure causal explanation two factors were borne in mind by the author:

(1) The knowledge and way of thinking, children brought to bear on the causal situation they were being questioned about.

(2) The "expected levels of achievement" of the children in each causal situation.

In drawing up the response guide for the initial causal component then, "actual" and "expected" nature of explaining the various causal situations were borne in mind.

Category Modification and Scoring Procedure

The effect of applying a second probe in the appreciation of initial causal components meant two different explanation categories might be given. A system of modifying the responses to the probes into a 'collapsed Category' was then devised to give one record. Below, is a system devised by the writer to arrive at the nature of the 'collapsed category' for probing initial causal components.

Example of an N_4 Modification

	Probe 1	Probe 2	'Collapsed Category'
Case (i)	N_4	N_4	N_4
Case (ii)	N_4	N_3	N_3
Case (iii)	N_4	N_2	N_2
Case (iv)	N_4	N_1	N_1
Case (v)	N_4	NN	N_4
Case (vi)	N_4	DK	N_4
Case (vii)	N_2	N4	N_2

As can be seen from the above the status of the highest category is taken as the overriding criterion for arriving at the "collapsed" or final category. This is irrespective of the position it comes in the probe.

Case (i) is straightforward (as it would be if two N_3, N_2 etc. were recorded). Both probes gave N_4 type answers but nothing more.

Case (ii) means that the N_3 of the second probe has increased the quality of the final explanation, adding to its value as a causal explanation.

Case (iii). Again, the higher N_2 of the second probe, has added to the quality of the causal explanation and the collapsed category reflects this by recording a final N_2.

Case (iv). Similar to case (iii).

Case (v). Here, no more is added of a naturalistic nature to the explanation, even after a probe so, it remains an N_4 category explanation.

Case (vi). The same as for case (v).

Case (vii). Here, the first explanation was of a good quality while the second reverted to a one word response, which did not add anything by way of criteria (b), (c) and (d) (see page 175). So the highest awarded category given in response to the first probe gave a final N_2 in this case. The fuller details of the system for all possible collapsed levels of explanations are to be found in Appendix A_2.

Scoring of N* Categories

A category N_1 explanation was awarded 5 points

A category N_2 explanation was awarded 4 points

A category N_3 explanation was awarded 2 points

A category N_4 explanation was awarded 1 point

**NN and ***DK categories were treated as 0. Because of the superior nature of N_1 and N_2 categories of explanation, it was considered by the author that the 'psychological distance' between these and categories 3 and 4, could be reflected in the higher award of points.

For developing longitudinal scoring profiles (see Chapter 10 and Appendix $E_{2,3,4}$) the following system was adopted. If a S had

* The N is dropped in the presentation and discussion of results with Response Categories 1 - 4 being used.

** The NN is dropped in the presentation and discussion of results with Response Categories 5 being used.

*** DK is dropped in the presentation and discussion of results with Response Categories 6 being used.

recorded a pattern of categories of explanation for an item, the categories were collapsed using the same system explained earlier so giving a final categorisation. A final categorisation was recorded for each of the three testings in the longitudinal design. From three testings, a modal pattern embracing three final collapsed categories of explanation emerged. Table No. 7a shows the method of developing final categories and modal patterns. The development of this system of categories for longitudinal data, is termed by the author Modal Pattern Analysis (MPA).

Table No. 7a Showing Procedure for arriving at final categorisation and a resultant modal pattern for a 3 test longitudinal design.

Subject Tested X		Stimulus Item Y (e.g. origin of rain)		
Longitudinal Testing	Probe	Category of Explanation Awarded	Collapsed Category yielding a Final Cat-egorisation	Resultant* Model Pattern for 3 Longitudinal Testings
1st	1st	4	3	3 - 2 - 2
	2nd	3		
2nd	1st	4	2	
	2nd	2		
3rd	1st	4	2	
	2nd	2		

* More details will be given concerning these patterns in Chapter 10.

ii) Categorisation and Scoring of Responses to the Pluralistic Causal Component

Three categories of response were employed for the questions probing plurality, these are:

+ given to a response which gave a cause different from that given as a result of probes 1 and 2.

- was given when the response was "no".

DK given to a stated don't know or a shoulder shrug.

Scoring

Where a + response was recorded, a value of 1 was given.

The + response meant that a child was able to appreciate that a causal condition may have not just one cause or set of causes, but another cause or set of causes.

The registration of a - response meant, that no other cause or set of causes were responsible for the effect probed in questions 1 and 2.

iii) Categorisation of Responses to the Probabilistic Causal Component

Three categories of response were employed for the questions probing probability these are:

+ given to a response which gave a probable cause out of the ones stated. *

- given to a response which gave a no to the probe.

DK given to a stated "don't know" or shoulder shrug.

* where a cause was stated which did not occur in the ones mentioned this was included also as a +.

No score was given to this component, as it was considered to be fairly simple intellectually speaking being no more than an indicator of choice in the present investigation. Although the whole area of causal probability is by no means simplistic, a depth of study into this field was beyond the scope of this investigation. The + response meant an appreciation by the child of a probable cause condition, while the - response suggests no probability exists.

iv) Categorisation and Scoring of Responses to the Logico-Causal Component

Again three categories of response were employed for the questions probing this component.

+ was given to a response which showed that a particular cause or set of causes was responsible, and in certain cases more responsible than another cause/causes. The + response meant that the child was not only able to appreciate that some form of causal probability exists, but attempt to logically explain it in a causal context.

- was given to a child that merely described the probability rather than accounting for it.

DK given to a stated "don't know or a shoulder shrug.

Scoring of Categories

A value of 2 was given for a + .

v) Categorisation of Responses to the Experiential Causal Component

Five categories of response emerged for the questions probing this component. Although, it is possible that several sources of experience may be responsible for answers to questions of causal origin, the first consistent response was taken as the one most likely to contribute to the response.

The response was also seen as relating mainly to probes 1 and 2 and therefore shedding light on the initial causal component.

<u>Familial</u> - this category covered several sub-categories, extra and intrafamilial. The extra-familial included friends, while mother, father, siblings, cousins etc. make up the intra-familial category. Although these sub-categories were written on the Recording Sheet (Appendix C_2) only the global category <u>Familial</u>, has been presented in results in Chapters 9 and 10. Although where applicable reference may be made to the sub-categories on some occasions.

<u>Self</u> - this category was given for responses where the self was mentioned e.g. "I did it myself ......, I saw it ......" etc. The emphasis was on the person doing or experiencing.

<u>Media</u> - this category was given where the source is actually mentioned. Again, sub-categories emerged in the pilot studies which were retained for recording purposes. These sub-categories were television, daily paper, radio. Again, only the global category Media has been presented in the results.

<u>Books</u> - this category was given to sources cited as reading material other than daily papers. Three sub-categories emerged as the main sources under this heading, books read from the school library, books owned and read at home and books read in the public library or borrowed from the library. Again only the global term is presented in the results.

<u>School</u> - this category was given to responses which cited activities carried out in class, or on school visits or visitors into the school which give them incidental information on a particular causal situation. Again, only the global term <u>School</u> appears in the results.

The designation given for each category was:

F - familial (1)*

S - self (2)*

M - media (3)*

B - books (4)*

C - school (5)*

The categories for this component are descriptive and therefore no metric value was given to them:

(d) <u>Validity of the Physical Causality Test Battery</u>

The majority of the stimulus items used in in the Physical Causality Test Battery have also been employed by previous workers Piaget (1930), Nass (1956), Berzonsky (1969) etc. and so this contributes appreciably to the validity of the test battery. The work carried out in the pilot studies also contributed to a substantial re-designing of the instrument, adding further to the validity of this instrument.

8.1.2. <u>Causal Demonstration</u> - <u>The Water Level Test</u>

(a) <u>Rationale for the test</u>

This test has been modified after Piaget's (1930) original procedure, and was given to the children as an example of a causal demonstration. The test presents the child with a practical causal situation. It there-

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* Numbers represent numerical designation

fore gives an opportunity for the child to explain a causal situation in "action" terms. From an educational point of view too, it gives an opportunity to compare children's explanation in a verbally presented causal situation as in the Physical Causality Test Battery, with a more practical presentation such as this.

(b) <u>The Nature of the Test and response Categorisation and Scoring</u>

Exact details of the test are given in Appendix A_3. However, briefly this instrument consists of five parts, a <u>preliminary</u> part designed to establish rapport between E and S and to introduce the apparatus. The second part probes the S's ability to <u>predict</u> the level the water will rise to, if the ball bearing is put into the water. This is followed by a third part in which <u>action</u> takes place concerning the ball bearing. Part 4 is <u>another predictive</u> section in which the clay is involved. This is followed by Part 5, <u>another action</u> phase, in which the clay is actually immersed, and a question posed concerning a comparison between why the two different substances give the same levels. <u>Question 21</u> is the one that is categorised and scored, as this is the key question probing causality. The categorisation follows the same scheme as for the initial causal component in the Physical Causality Test Battery i.e. the award of explanation categories N_1 to N_4, NN or a "don't know". The scoring is based on the same value of points i.e. 5 points for an N_1 a 4 points for N_2 a 2 points for N_3 and a 1 point for N_4.

(c) <u>Validity of the Test</u>

This is a well established Piagetian test, used by many workers and found to be valid as a causal measure, as well as a measure of volume appreciation.

8.1.3 The Causal Reasoning Tests

(a) Rationale for the Tests

This is a series of non-standardised tests developed mostly by the author to probe further, a child's appreciation of causal conditions in addition to the ones probed in the Physical Causality Test Battery. Several parts of this test have been modified after the work of Berzonsky (1969), and are acknowledged by the insertion of an asterisk.* The conceptual framework developed by Wartoffsky (1962) discussed in Chapter 2 forms the basis to several of the sub-tests described below.

(b) The Nature of the Tests

The details of the test are to be found in Appendix A_4, but a brief description of the main parts will be given here, together with the mode of response categorisation and scoring.

The test has eight sections, each dealing with an area that is related to an appreciation of a causal condition. Each section has three sub-tests, two verbal and a demonstration, involving S activity. In all, there were 24 encounters per S. The eight sections are as follows:

1. Detection of Cause and Effect - this attempts to establish whether or not the S can recognise the cause/s of an effect, as well as the effect/s typified in selected causal situations.

2. Causal ground - this attempts to probe whether a S can appreciate that some effects have an origin removed in time, and that a series of events lead up to a final effect or condition.

3. Invariant Sequence - this attempts to probe whether a causal condition is invariably borne out in practice. The S should be able to detect that in some cases a certain effect follows automatically as a result of a causal agency or agencies.

*4. Detection of chance events - this attempts to probe a S's appreciation of a chance situation. Chance is a likely element that comes into the explanation of causal conditions, and an appreciation of the process may give some further light, as to whether this type of appreciation is related to overall appreciation of causality.

*5. Detection of an incongruity - this attempts to probe a S's ability to recognise incongruous elements in a causal statement, so that the E obtains a measure of the S's sharpness in thinking, and ability to assess up the logicality of a causal statement. This can be considered to be an extension to the logico-causal component, probed in the Physical Causality test.

6. Causality in terms of action - this attempts to probe whether a S can detect that an effect may be the result of surface force e.g. the impact of a bottle falling on to the floor, or whether the effect has been produced through action at a distance e.g. the sun's rays producing warmth etc.. Finally, whether an effect may be produced as a result of some line of action on the part of a person e.g. wishing something to happen.

7. Contingency and Necessity - this attempts to probe whether a S can detect contingency in certain causal conditions but not a necessary contingency ; or in other cases of a causal condition, the cause/s will produce not only a contingency but a one and only contingency producing a necessary effect.

8. Retroactive Causality - this attempts to probe whether a S can indicate that in some causal conditions the cause/s - effect/s can feed back into each other. However, if the S has revealed a level of causal appreciation, he should be able to detect the initial cause or set of causes in the feedback process.

(c) Categorisation and Scoring of Responses

Four categories were used to classify the responses these were:

+ given where a clear appreciation of the causal or the related condition is registered by a S.

- where there was a clear indication or no appreciation of the causal or related condition.

T where there was an ambivalence in the response given.

DK registered for S who have shoulder shrugs or "don't knows".

Scoring all + responses were given a value of 1 and this was totalled for the test.

(d) Validity of the Causal Reasoning Tests

Sub-tests 4 and 5 were based on Berzonsky's work, and after slight modification during the pilot studies, the author incorporated them into these tests. It was apparent from the results of the pilot studies these tests were following similar patterns to those of Berzonsky and therefore provides a reasonable basis for their validity as measures. Tests 1, 2, 3, 6, 7, 8 were devised by the author, piloted and modified in the light of the findings of the pilot study.

8.1.4. Causal Problem Solving Test - Electric Light Problem

(a) Rationale for the Test

This is an original test devised by the author as an example of combined verbal, demonstrational and child - based practical activity, focused towards a causal problem solving strategy. It was given to the S to probe the more operational aspects of causal thinking and involved several stages. From an educational point of view, it explores the relative merits of verbal, demonstrational and actual S practical involvement, and the subsequent effect these approaches have on the appreciation or otherwise of solving a problem in science, and moreover in a causal context.

(b) The Nature of the Test

Details of the test are given in Appendix A_5. However, briefly the instrument consists of five phases. The first phase is instructional and introductory showing and naming the apparatus but not explaining the construction of the circuit.

The second phase is explanatory in which the S, having constructed the circuit and got the light to come on, has now to explain how he has produced the effect of lighting up. From the actual questions in Appendix A_5, it can be seen that probes 2, 2a are akin to those for probing initial causal appreciation, 3a is akin to probing causal plurality while 4, 4a and 5 probe causal probability, and any consequent logico-causal explanation.

The third phase is confirmatory

The fourth phase is a preparatory phase of unrelated activity for phase 5, which represents a practical situation of a malfunctional phase, to test the S's ability to think more closely about the causal condition, and if possible to ohallenge the E.

(c) Categorisation and Scoring

This is an extensive test and time did not allow the E to develop it in the way that the Physical Causality Test was done. A scoring system was devised, and is closely related to the scoring system used for the various components in the Physical Causality Test Battery. In other words, categories $N_1 - N_4$, NN and DK were used, and similarly scored. Questions employed in other parts of the test were also scored. The complete scoring schedule is as follows:

Question	2	up to	5	points
"	3	" "	2	"
"	5	" "	5	"
"	6	" "	5	"
"	9	" "	5	"
"	10	" "	2	"
Total			24	

(d) Validity of the Test

The present test is the result of several exercises carried out by E on first year middle school children in the pilot school, and although this is a non-standardised test, it appeared to produce similar overall trends, even with a mini-exercise carried out in the experimental school.

8.1.5 The Bicycle Drawing Test

Rationale for the Test

This test was based on Piaget's (1930) original procedure and modified by Jahoda (1969). The reasoning behind the presentation of the test was to find out how first year middle school children, understand and communicate their appreciation of a causal situation applying motor skills involved in drawing. Also, as a bicycle mechanism was a stimulus item appearing in the Physical Causality Battery, it was thought by the author to be interesting to compare, a verbal explanation and an appreciation of the same task through drawing of a familiar causal situation, much along lines of Piaget's original and more recent work.*

* However the results of this particular comparison are not included in this thesis due to lack of time.

(b) The Nature of the Test

The task was applied on a class basis and Appendix A_6 shows the instructions given to the teachers to perform the testing.

(c) Scoring Procedure for the Drawing

The scoring was linked to the salient mechanical elements involved in the working of the bicycle. These elements are:

(1) Two wheels

(2) a cog between the two wheels

(3) a pedal attached to the cog wheel

(4) a cog wheel in the centre of the rear wheel

(5) a chain surrounding the two cog wheels

Other features like handle bars etc. were ignored. A value of 1 point was given to each of the 5 elements mentioned above. This gave a possible total score of 5 points.

The test was administered after the Physical Causality Test Battery was given, so that the verbal explanation of the bicycle mechanism preceded the drawing of it.

(d) Validity of the Bicycle Drawing Test

The task is a well tried one, and has been used with several age ranges and in different cultural contexts (Jahoda 1969).

8.1.6 . A Creativity Measure of Causal Appreciation

(a) Rationale for the Test

This test was given in order to probe the creative element in the way children appreciate a causal situation. The test devised by Torrance (1966) was the one of seven called causes. The wording of the original test was slightly modified replacing the word "cause" by "making". This change, is in line with the questioning procedure used elsewhere in this investigation in the tests of causal appreciation. The pilot studies indicated to the author, especially in the appreciation of causal plurality, that a creative dimension might be related to this component, a component which to some extent taps childrens' "creative strength" in causal contexts.

(b) The Nature of the Test

As devised by Torrance, with changes in the instructions mentioned above. Appendix A_7 contain the details of the instructions given to the teachers by the author and the S's response form.

(c) Scoring of the Responses

This followed the detailed instructions given by Torrance. Three aspects of causal creativity were scored namely:

Fluency

Flexibility

Originality

A separate score was obtained for each of these aspects.

(d) Validity of the Test

This is a standardised test having a recognised internal and external measure of validity.

8.1.7. Use of Causal Connectives Test

(a) Rationale for the Test

This test was given to compare performance on language specifically making use of causal connectives, and the appreciation of causal situations which invariably use causal connectives to communicate this appreciation. Part of the test has been developed along lines used by Berzonsky (1969). However, in this investigation not only complete-type questions were asked but construct-type ones were also probed. The construct-type question requires more thought on the part of Ss, and seemed to be an interesting ability to compare with their appreciation of the various causal components.

(b) Nature of the Test

Details of the test can be found in Appendix A_8. However, briefly the test probed two modes of language ability - completion
- construction

Completion involved presenting the S with an unfinished sentence ending in a causal connective or causal connecting phrase, which was then to be completed by the S. verbally; e.g. The boy came off his bicycle because ...... Construction involved the S constructing a whole sentence verbally with a causal connective, e.g. making up a sentence using because.

The causal connectives and causal connecting phrases, were chosen in consultation with teachers in the pilot and experimental schools. They are as follows:

because

therefore

but

as

* as it makes

* due to

* These were included as they appeared to be much in use by the teachers in the pilot school, especially in science lessons.

In order to get a representative picture of children's ability in using causal connectives, it was found necessary to get S's to complete and construct three examples of each connective, giving 36 sentences in all.

The procedure included asking the S to verbally complete and construct sentences with each of the six connectives. The sequence being, completion followed by construction for each set of connectives.

(c) Categorisation and Scoring of Responses

Three categories of response were used these are:

+ if the response given was correct

- if the response given was incorrect

DK if shoulder shrugs or "don't knows" were observed.

The criterion for correctness was a perfect completion or construction of a consequence situation. The connective had to link cause/s with an effect or effects. If this did not occur, it was deemed an incorrect usage of a causal connective. A separate score was obtained for each set of completion and construction items, by adding up the + ves only.

(d) Validity of the Causal Connectives Test

The use of the completion part by Berzonsky produced similar results to those of the author's in the pilot studies. Also several versions of the test were produced during the pilot study, resulting in much checking and rechecking with selected school staff, before the present instrument was finally applied to Ss in the experimental school.

8.2 Instrumentation for Measuring abilities other than Causal but which may be related to appreciation of causal situations

8.2.1 Relational Test

(a) Rationale for the Test

This was given to the children to probe their ability to understand relationships involving persons, shapes etc. No items in the test were causal and this was deliberate on the part of the author, in order to get an independent measure of relational ability. It was intended to compare performance on this measure with the S's performance on the causal tests, which also probe childrens' appreciation of relationships but in a causal context.

(b) Nature of the Test

Four questions are asked in this test, one of which involves a demonstration card with three shapes on it. Details of the whole test are to be found in Appendix B_1. An introductory part precedes the probing similar to other tests.

(c) Scoring of the Test

Questions 1 and 2 has a total of 5 points each, question 3, 4 points, question 4, 6 points, giving a total of 20 points.

(d) Validity of the Test

This type of test has many well tried items and appear in the work of Piaget as well as tests measuring achievement. Most of the items were based on such experience, and the item involving a test card with shapes on it, was modified after Berzonsky (1969).

8.2.2 Judgemental/Verification Test

(a) Rationale for the Test

This was given to the children in order to probe their ability to judge and verify certain conditions. Judgemental and verificational processes are salient in any scientific experimentation, and this would apply equally in appreciation of a causal situation. The ability therefore to weigh up and verify possible causes of an effect, would seem to be an important ability entering into the process. It was for these reasons that this test was included.

(b) Nature of the Test

The exact details of the test are to be found in Appendix B_2, but briefly the test consists of a judgemental phase in which 2 pieces of metal are presented to the S, and questions are asked about their weight. This phase is then succeeded by a phase of verification, in which an accurate verification is required of the S.

(c) Scoring of the Test

1. 2 points are awarded if the S responds by picking up the rectangular metal shapes, no award is otherwise given.
2. a further 2 points are awarded if the S responds by using a spring balance placed in the vicinity of the S to accurately verify the weight.

2a. if the S gives a rough verification using his hands as a weighing machine 1 point is given in 2 above.

(d) Validity of the Judgemental/Verification Test

A series of trials during the pilot study produced several modifications to the original test in order to obtain a valid measuring instrument.

8.2.3. Scepticism Test

(a) The Rationale for the Test

Sceptical elements in thinking about and explaining causal situations have been the subject of some of Berzonsky's work into causal reasoning. The inclusion of scepticism as apart of scientific explanation, has also been a trend in the more recent secondary school science curriculum SCISP (1974). It was therefore decided, to include a test of scepticism in this investigation to see what relationship if any, exists between the test and their performance on other causal measures.

(b) Nature of the Test

The statements and questions appear in Appendix B_3. The S is asked to comment after each statement and question, has been read out by the E.

(c) Categorisation and Scoring

Categorisation

A +ve response was awarded for each response which showed evidence of a sceptical nature. Scepticism criteria, included the S's ability to show caution in his remarks relating to the question, and/or showed an ability to weigh up the pros and cons of the statement, and/or showed an ability to challenge some of the assumptions in the statements.

a -ve response was awarded where there was no evidence of the above criteria in the responses of the S.

DK was awarded where the S said don't know or gave a shoulder shrug.

Scoring of Categories

1 point was given for every + response recorded for a question, giving a total of 5 points for the whole test. No values were given to other categories.

(d) Validity of the Scepticism Test

Some of the items included in the test were based on those used by Berzonsky. Also the pilot studies showed the need to rewrite many of the statements and related questions, until a satisfactory level of validity was attained.

8.2.4 Conservational Tests

(a) Rationale for the Tests

Four conservational tasks were given to the Ss; conservation of substance, weight, area and volume. These tasks were selected in order to compare, how children performed on classical Piagetian operational tasks, with their appreciation of causal situations.

(b) Nature of the Tests

Exact details of the 4 conservational tests are to be found in Appendix B_4. However brief comments are given here on the modifications made to the methodological procedures of Piaget's original tests. All four tests follow Piaget's original framework but some of the experimental procedures closely follow those used by [Lovell (1961, 1962), Thomas (1971)]. Each of the conservational tasks were sequenced between non-conservational tasks to discourage the effect of practice. However all tasks were administered on the same experimental occasion in Batch B - see Chapter 7 page 153.

(i) Conservation of Substance

This was confined to conservation of liquids and contained the two presentations :-

a) a liquid - pouring into a tall thin vessel

b) a liquid - pouring into several small vessels (atomism).

(ii) Conservation of Weight

No special comment is given here as it follows the procedure used by Piaget except that a spring balance was made available if a S required verification of equivalence.

(iii) Conservation of Areas

This followed the procedure originally described by Piaget et at (1960) but was further based on the work of Lovell et al (1962) and consisted of three sections. Section A is a straight conservational procedure, in which one of a pair of rectangles is cut into two equal triangles and placed before the S.

Sections B and C are devised so that the E gets a much more precise idea of the S's appreciation of area by comparison with a measurable unit in the form of a square for sub-section 2 and a triangle for sub-section 3.

(iv) Conservation of Volume

This followed the procedure of Lovell and Ogilvie (1961) and consisted of three sections. Section A probed the appreciation of Internal Volume while Section B probed the appreciation of Occupied Volume and Section C Complementary or Displacement Volume.

(c) Categorisation of Responses

The scheme of categorisation followed the following pattern:

(i) Conservation of Substance

+ was awarded only if the S could conserve on the two presentations.

- was awarded if the S did not conserve.

T* was awarded if the answer to the final question in both presentations was -ive when the response to the predictive question was +ive. DK was awarded if S said "don't know" or gave a shoulder shrug.

(ii) Conservation of Weight

+, was awarded only if the S could appreciate sections A B C and D.

T was awarded when a + ive was awarded for the predictive parts and a - ve for the Action and Explanatory parts.

DK was awarded if the S said"don't know" or gave a shoulder shrug.

(iii) Conservation of Area

+ was awarded when the S showed appreciation of all three sections A, B, C.

- was awarded if the S did not respond positively on all three sections A, B, C.

T was awarded if the + response were recorded on Section A and B, but not C.

DK was awarded if the S said "don't know" or gave a shoulder shrug.

(iv) Conservation of Volume

+ was awarded when a S showed appreciation of conservation on all 3 sections A, B, C.

- was awarded when a S showed no appreciation of any of the 3 sections A, B, C.

T was awarded when a S gave + responses on sections A and B, but not C.

DK was awarded when a S gave a "don't know" or a shoulder shrug.

* T = Trsnsitional Category

(d) Validity of the Conservational Tests

All four conservational tests are well tried out and on this basis the validity of them was taken as acceptable. Results of pilot studies carried out by the author also supported the past findings of Piaget and Lovell.

8.2.5 The Richmond Achievement Tests

(a) Rationale for the Test

The results of some of the battery were used in this investigation on the basis that an independent, standardised measure is useful for the purpose of comparison, so that what relationship if any exists between causal appreciation of first year middle school children and their performance on measures of achievement can be examined. The Richmond Test was currently being used in the experimental school.

(b) The Nature of the Test

The test consists of 11 sub-tests. These are as follows:

(1)	Vocabulary	* (7)	Map interpretation
(2)	Reading	* (8)	Graphic "
(3)	Spelling	* (9)	Reference
(4)	Capitals	*(10)	Mathematical ability
(5)	Punctuation	*(11)	Problem Solving
*(6)	Word Usage		

(c) Scoring of the Richmond Achievement Tests and their validity

This is a standardised battery and is used quite frequently in British Middle Schools. For details of scoring and standardisation the reader is referred to Hieronymus, Lindquist, France (1974).

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* Only those sub-tests marked with an asterisk were selected for the treatment of results.

CHAPTER 9

STATEMENT, TREATMENT AND DISCUSSION OF THE DATA FROM THE FIRST YEAR STUDIES

CHAPTER 9

STATEMENT, TREATMENT AND DISCUSSION OF THE DATA FROM THE FIRST YEAR STUDIES

INTRODUCTION

The primary data for the whole investigation is found in Appendix H, much of this data is summarised in the form of tables, graphs, and values derived from several statistical treatments e.g. means, correlation coefficients etc..

In this chapter, a discussion of the results related to research questions and hypotheses emanating from Guiding Statement 1 will be presented. This statement is as follows: To establish the nature of causal thinking in first year middle school children and to examine this in relationship to other abilities; for further details of the research questions and hypotheses refer to Chapter 6.

In Chapter 10 the discussion will concern itself with the research questions and hypotheses related to Guiding Statement 2, a statement of which can be referred to in Chapters 6 and 10.

This chapter is divided into two main sections :-

9.1 Presentation and Discussion of the Descriptive Data from the application of the Physical Causality Test Battery (PCTB) - Descriptive Statistics.

9.2 Presentation and Discussion of results of a Factor Analytical Study of Causal Thinking.

9.1 Presentation and Discussion. the Descriptive Data from the application of the Physical Causality Test Battery (PCTB) - Descriptive Statistics

The results for this discussion are presented in Figure Nos. 6 - 10 and Tables Nos. 9 - 11. A general consideration of the main trends shown in the distribution of responses to the three types of stimulus material, will form the first part of this section. This will then be followed, by an examination and discussion of trends for the individual items.

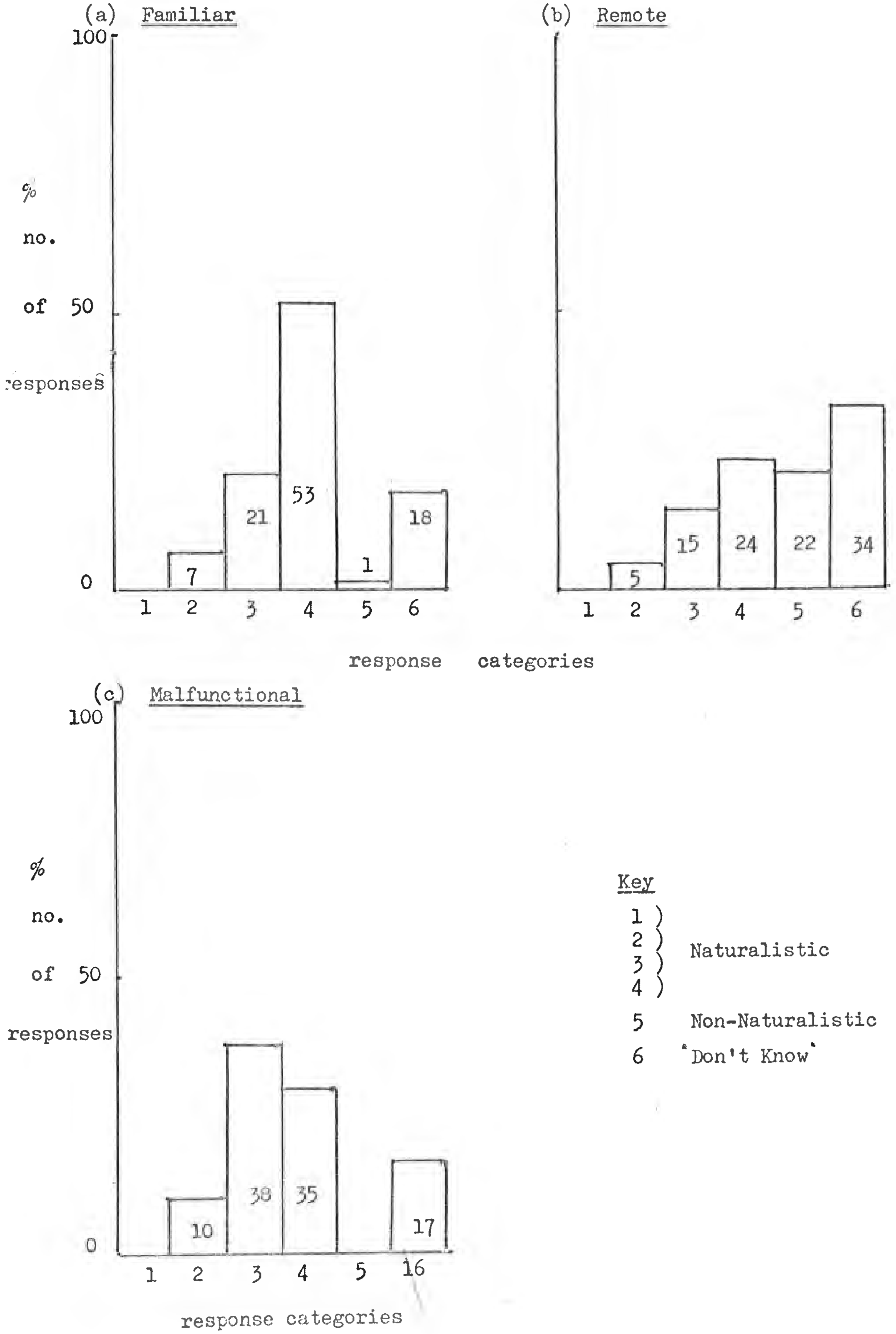
9.1.1 General Trends for the Three Types of Stimulus material

(a) Familiar Stimulus Material (Refer to Figure Nos. 6a, 7a, 8a, 9a, 10a)
Responses to familiar stimulus material do not include any category 1 explanations for the initial causal component. The bulk of responses were distributed between category 3 and 4 with many more for 4. Only a small number of category 2 explanations were registered, while pre-causal explanations (Category 5) account for a meagre 1%. The 'don't knows' (Category 6) was a surprising 18%, considering the choice of items within this familiar group. From these results it is clear that the bulk of explanations for causal phenomena of a familiar type, are either one or two word responses, or statements in which the relational structures are weak. The number of explanations having a high quality of relational and causal appreciation i.e. category 2 was low.

Just under a quarter of responses for the causal plurality component were positive, just over a quarter were negative and the majority were don't knows. As for the responses to the probability and logico-causal components are concerned, high concentrations of 'don't knows' indicate the

Figure No. 6 showing % distribution of responses to three types of causal stimulus situations for the initial causal component

(N = 102, number of response per situation = 612)



difficulty Ss had in appreciating these areas of causal thinking. Most of the responses given to the experiential component were almost equally distributed between the "familial" and "self" categories, while the other categories were well behind.

(b) Remote Stimulus Material (Refer to Figure Nos. 6b, 7b, 8b, 9b, 10b)

Responses to the remote stimulus material show no category 1 explanation. A striking feature in the shape of distributions in Figure No 6b is that no response category commands the dominance that 4 does in Figure No. 6a. However, responses to remote causal situations elicit over a third "don't knows", indicating the difficulty these situations have for the Ss. A quarter of the responses are non-naturalistic and the remainder are distributed unequally between categories 3 and 4. In company with the findings of Berzonsky (1969) and Nass (1956) the distribution of non-naturalistic responses reported here is perhaps not an unexpected result.

The number of positive responses to both pluralistic and probabilistic components are small, while numbers of "don't know" responses are large, and very large for probability. The distribution of responses to the logico-causal component, shows similar trends with a high concentration of "don't knows".

In company with the high levels of "don't knows" for other components, a large "don't know" distribution compared with the familiar and malfunctional stimulus material is not unexpected.

(c) Malfunctional Stimulus Material (Refer to Figure Nos. 6c, 7c, 8c, 9c, 10c)

Again the % distribution for this stimulus material does not indicate a category 1 explanation. However there are large distributions of category 3, 4 and a slight increase in the numbers of category 2 compared

Figure No. 7 showing % distributions of responses to three types of causal stimulus situation for the pluralistic and probabilistic causal components
(N = 102, number of responses per situation = 612)

Causal Plurality Component

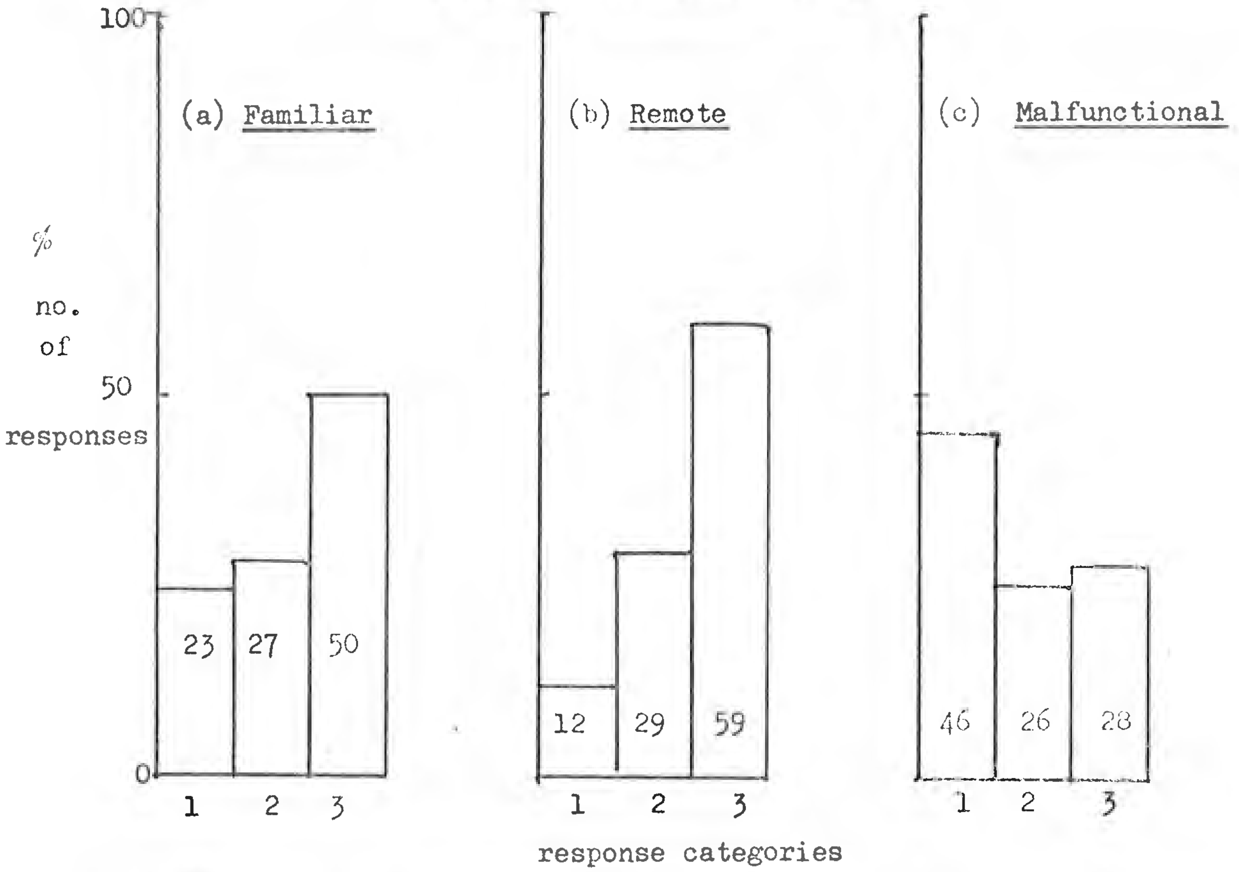
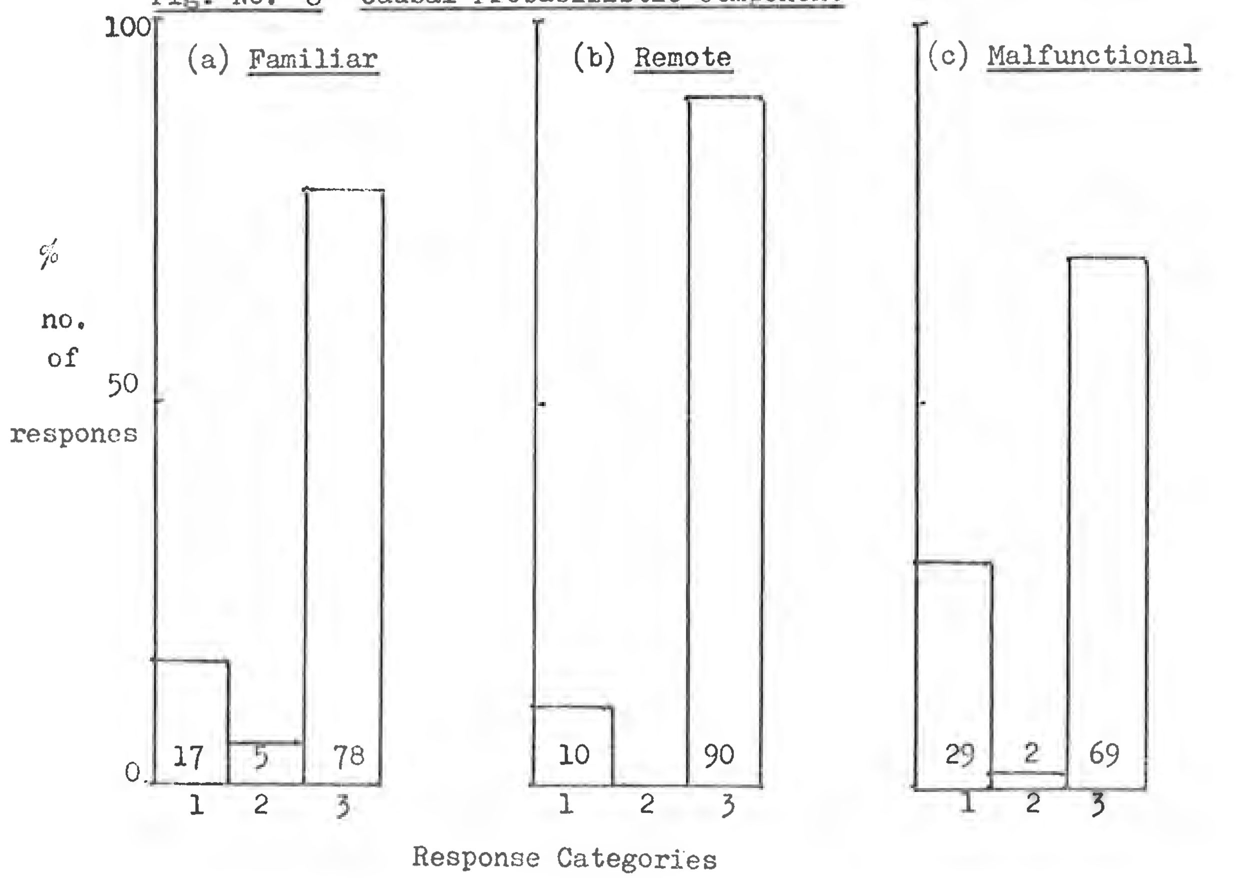


Fig. No. 8 Causal Probabilistic Component



Key 1 = +ve 2 = -ve 3 = "Don't know"

Figure No. 9 Showing % distribution of responses to three types of Causal Stimulus situations for the logico-causal and experiential causal component (N = 102, possible number of responses = 612)

Logico-causal component

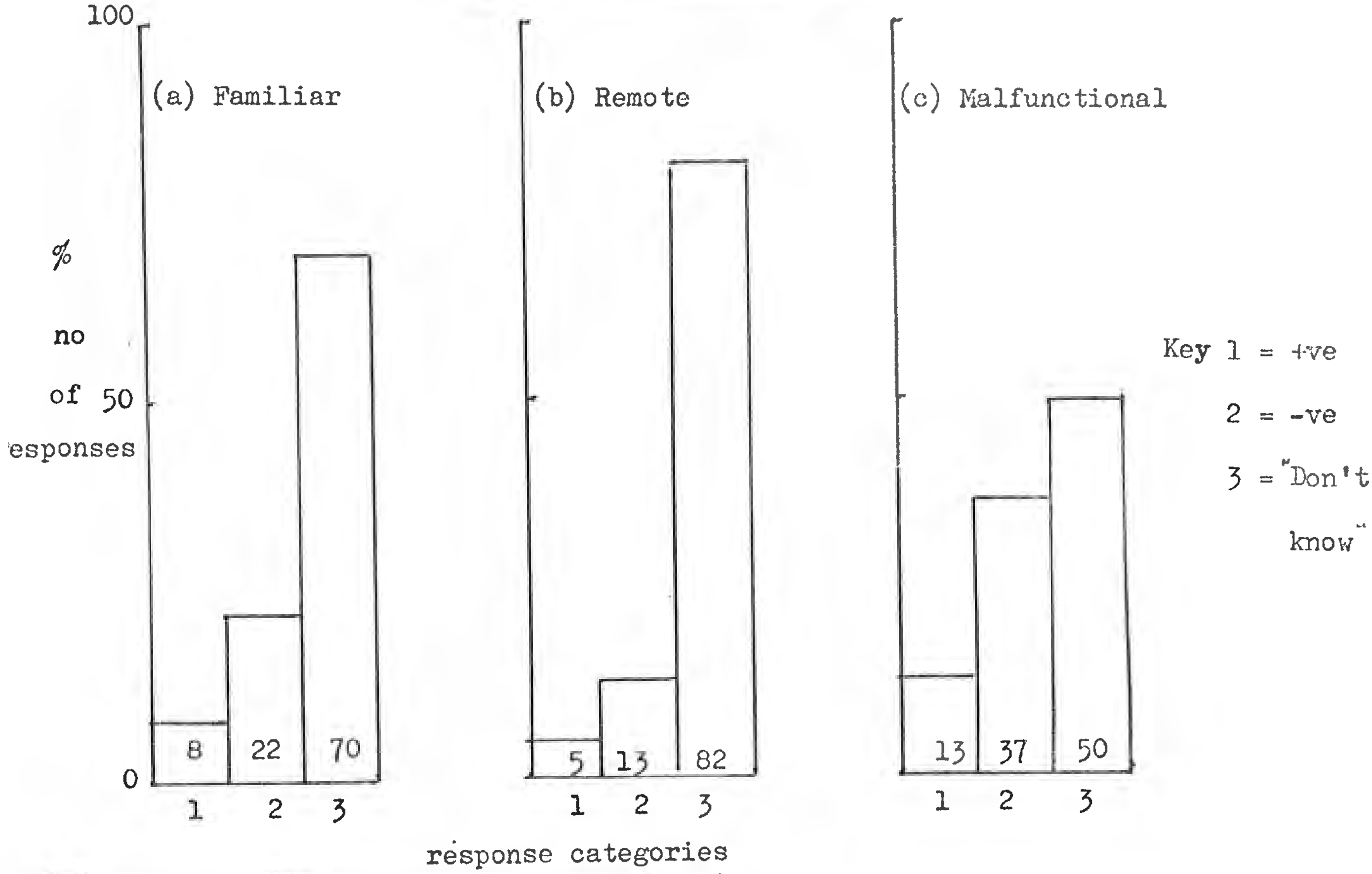
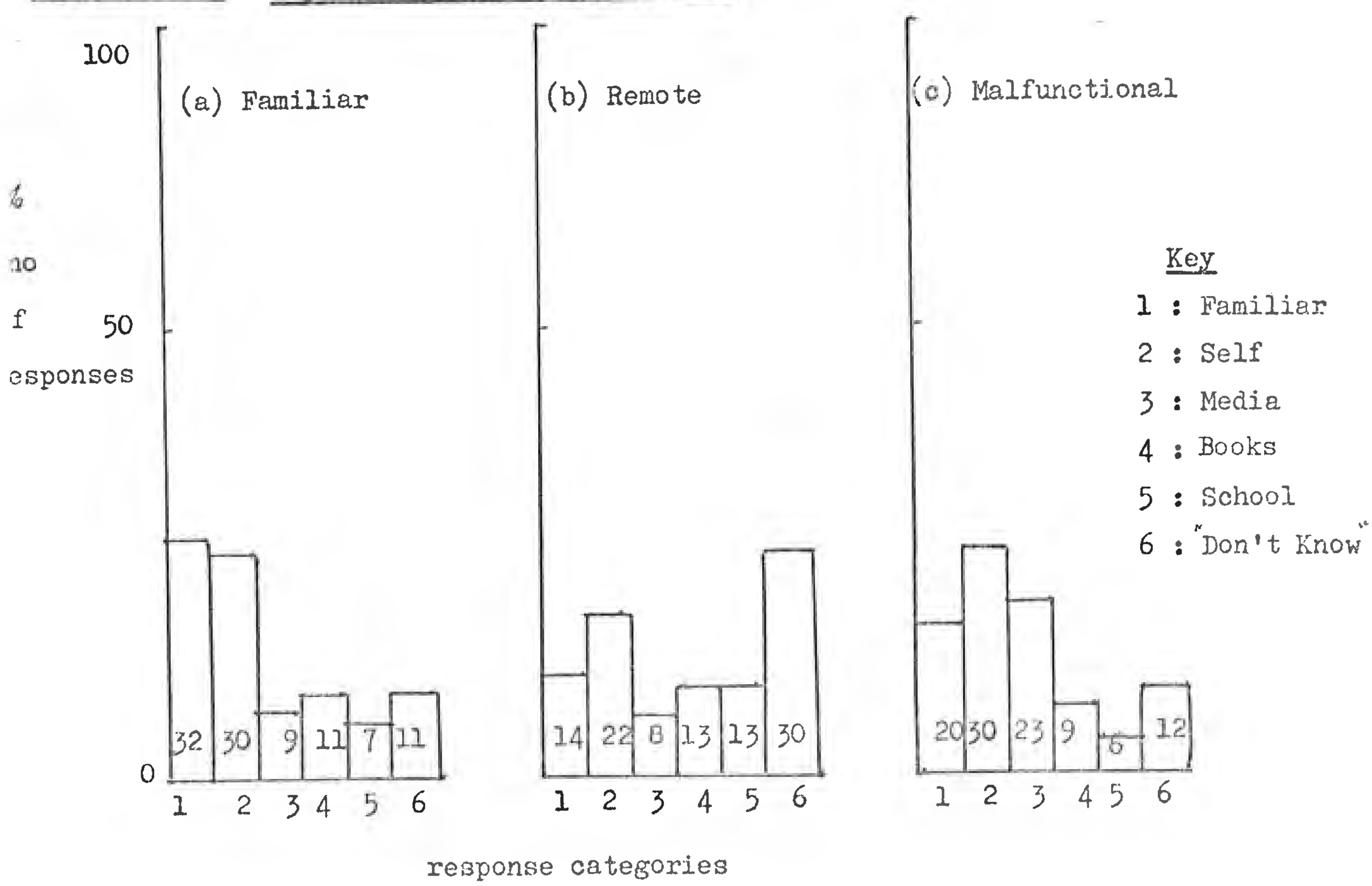


Figure No.10 Experiential Causal Component



to that for the familiar material. Clearly, malfunctional situations elicit more responses that have the traces of relational thinking in them. The distribution of responses to the pluralistic and probabilistic components, reflect relatively high numbers of positive responses, and even for the logico-causal components, the numbers of response are the largest for all three types of stimulus material. The distribution of responses to the experiential component, indicates a pre-dominance of "familial", "self" and "media" clustering.

(d) Discussion of the main trends

If the response categories 1 - 4 are telescoped as a blanket naturalistic classification, the results show an expected pattern in the light of previous work carried out by Piaget (1930), Nass (1956), Berzonsky (1969). In other words, children aged 9 and over for the most part, should be able to explain causal situations in at least a mechanical fashion. The non-naturalistic category suggested by Nass (1956), was however used in this study, and the results show such responses were recorded, indicating that pre-causal elements are present in these children's explanations, especially in their responses to remote stimulus material. Analysis of the individual items dealt with in the next section, shows that pre-causal responses were a particular feature of a specific stimulus item.

In considering the 4 individual categories devised by the author and subsumed under the naturalistic classification, the collapsing of % distributions for category 1 in the case of the six items for each type of stimulus material, means that the few category 1 explanations given (see Table Nos. 9 - 11) are masked by calculating a mean %. However as an overall trend, category 1, the highest quality explanation was not a feature. In examining the occurrence of category 2 explanations, up to 10% only are registered, and this is in the context of malfunctional causal situations. Again, in the malfunctional context, more category 3 responses are indicated than for either of the other types of stimulus material. The negative or malfunctional nature of a causal situation when presented to some children, obviously provides a more qualitative response. The occurrence of 'don't know' or category 6 response, has been taken as an indicator of the difficulty a particular item

TABLE No.8 Showing order of difficulty on the basis of % distribution for Don't Know answers for all 18 items - Initial Causal Component (N = 102)

Item	Type of Stimulus Material	Distribution	Order
Lightning	Remote	42	1
Rain	"	40	2
Dreams	"	36	3
Night	"	36	3
Birds	Familiar	31	5
Clouds	Remote	31	5
TV	Familiar	31	5
Clocks	Malfunctional	30	8
Boats floating	Familiar	27	9
Motor Car	"	20	10
Train Crash	Malfunctional	18	11
Glass breaking	"	15	12
Death	"	15	12
Space	Remote	14	14
Plants	Familiar	13	15
Bicycle	"	13	15
Balloon	Malfunctional	10	17
Boats sinking	"	9	18

elicits. (See Table No. 8). When the 6 items for each type of stimulus material is collapsed, and a mean % presented as in the various figures and tables referred to in this section, the remote group of items present the greatest difficulty for the Ss interviewed in this study.

Response distributions for the pluralistic, probabilistic and logico-causal components are characterised by a gradient of high numbers of +ives for malfunctional to familiar to remote stimulus materials, the latter having low numbers of +ive responses. Once again, the malfunctional content appears to provide conditions for providing a more qualitative level of causal analysis.

The results for the experiential causal component provide an interesting underlying source of information, which may be able to explain the trends discussed here. It is perhaps expected, that for the familiar and malfunctional material used in this study; "familial" and "self" sources of information, would provide valuable information and even thinking strategies emphasizing relationships. The large number of "don't know" responses for remote items is, to some extent an expected result, but even here the highest number of responses recorded after category 6, was category 2 i.e. the "self." This shows that many children relied on their own experience to answer this type of stimulus material.

The low level of responses citing the school, and use of books as a source in the explanation of causality, indicates what little impact these channels of experience have on the way children appreciate cause and effect. An interesting trend concerned with this component, is the large number of responses giving the media (mostly TV), as a source of their information in answering the questions on malfunctional situations. Is it because the media, especially Television, tend to exploit the negative aspects of life, i.e.conflict, death, and that response to malfunctional causal situations are benefiting from a transfer effect?

9.1.2 Trends shown in the % distribution of responses to individual items comprising the three types of stimulus material

(a) Familiar Stimulus Items (Refer to Table Nos. 9a - f)

Car Movement

The largest number of category 4 responses was registered for this item, but an item that elicited amongst the least category 3 responses. This indicates, that although the movement of a car may be considered to be a fairly familiar activity, this familiarity is superficial. The workings of a car are difficult to explain, even for an adult and for most of the children tested here, their explanations mainly comprised of one or two word responses e.g. petrol, gear etc.. However, the relatively large number of logico-causal responses indicate, that where multiple causes are mentioned, the superficiality of category 3 and 4 explanations, is compensated for, by some of the Ss being able to give a logical deduction of why one set of causes or cause is the most likely. From an examination of the experiential causal component, the large concentration of familial responses, shows the influence of home background (mainly "father") that contributed to Ss appreciation of this item.

Boat floating and TV Mechanism

The % distribution of responses recorded for these two items indicate

Table No. 9 showing % distribution of responses to individual items of a familiar nature for the various causal components (N = 102)

(a) Car Movement

Response * Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		36	25	12	68
2	1	27	1	32	10
3	17	37	74	56	6
4	62				15
5					1
6	20				

(b) Boat floating

Response* Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		20	14	7	18
2	5	31	2	19	30
3	21	49	84	74	11
4	46				11
5	1				7
6	27				23

(c) Bird flight

Response* Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		15	27	2	12
2	1	36	2	20	40
3	13	49	71	78	12
4	54				11
5	1				18
6	31				7

* Consult Key to response categories in Figure Nos. 6 - 10

Table No. 9 showing % distribution of responses to individual items of a familiar nature for the various causal components (N = 102)

(d) T.V.

Response * Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		17	13	6	26
2	4	31	4	18	22
3	20	52	83	76	15
4	44				8
5	1				5
6	31				24

(e) Bicycle Mechanism

Response* Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1	1	30	22	14	31
2	15	36	4	25	54
3	35	34	74	61	3
4	36				5
5					3
6	13				4

(f) Plant Growth

Response* Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		20	15	4	38
2	5	36	1	19	25
3	31	44	84	77	6
4	51				16
5					9
6	13				6

* Consult Key to response categories in Figure Nos. 6 - 10

fairly similar trends in the various causal components. Apart from the fact that both items which are initially familiar, but like the workings of the car present rather an intricate causal mechanism to the child, little can be offered to explain the similarity. It could be, that the notion of density and the process of "wave action", which underpin any qualitative explanation of floating, and the television mechanism respectively, are equally intangible concepts when these Ss were probed to explain the causation.

Bird Flight and Plant Growth

These items represent living organisms, with the explanation of locomotion in the case of birds and growth in the case of plants. The % distribution of category 4 responses is very similar, although slightly more for birds. However, a marked difference exists in the larger number of category 3 responses registered for the plant growth item, and to a lesser extent for category 2 responses. Although both items are classified as familiar and both are living organisms, it seems that plant growth is nearer to the experience of children, and therefore presumably easier in this case to provide a higher form of explanation. The nature of this familiarity, may be further examined in the light of the large number of responses giving "familial", (mainly mother) sources of experience. Plants can be touched and even their growth can be measured over a short period of time in a fairly informal way at home.

Bird flight however, judging from the large number of don't knows is clearly more difficult to explain (see Table No. 9c). The complex activity of flight and the less familiar nature of birds - i.e. being unable to touch them in most instances, may be contributory factors for the small spread of responses over the categories. In looking at the results for the experiential component there is a high concentration on the numbers registering "self" responses. The information usually included under this category, was "I have seen birds fly" which means, that causality in most instances is being explained from afar, and therefore this too must be considered in the interpretation of these results. The trends for the other causal components are fairly similar and will not be discussed further.

Bicycle Mechanism

Of all the familiar items the mechanism of the bicycle elicits the highest number of category 2 and 3 explanations, and is the only instance in the list of familiar items where a category 1 explanation is recorded. The high numbers of responses registered for "Self" and "Familial" categories, lends support to a causal situation which is well known in a practical context, and is likely to promote a higher quality of causal explanation. The distribution of responses for the pluralistic, probabilistic and logico-causal components reflects the quality encountered for the initial causal component.

(b) Remote Stimulus Items (Refer to Table Nos. 10a - f)

Cloud Movement

Responses to this item are concentrated on category 4 and 6 respectively, for the initial causal component. There is some element of pre-causality, as shown by the number of responses registered for category 5. Clearly, one word explanations are the most common way of explaining cloud movement and with few category 3 type responses. The large number of category 6 responses, is reflected in the results for the pluralistic, probabilistic and logico-causal components. While the number of responses registered for the "self" category, is the highest for the item. A large number of responses were also registered for the school source. This is probably linked to the teaching of the rain cycle which was taught in conjunction with this study. However, what emerges here, is that teaching a topic which incidentally includes an important part of another process i.e. cloud movements and rain, may not be contributing much beyond the descriptive category 4 level of causal explanation for these Ss.

Lightning

From examining the distribution of category 6 responses, it is clear that the origin of lightning was difficult to explain (see Table No. 10b) The high number of category 5 responses also indicates the large element of pre-causal thinking, that exists for this item at the level of the initial causal component. The large numbers of "don't knows" is also reflected in the pluralistic, probabilistic and logico-causal components. However the spread of experiential sources may mean, that while about a third of responses are "don't know", the responses registered for "familial" and "self" are relatively high. The physical remoteness of lightning, and the abstract nature of electricity and its role in producing lightning, is probably a salient factor in the explanation of these results.

Space Ship Movement

The distribution of categories 2, 3 and 4 is interesting for an item such as a space craft, especially when the large numbers of responses given

Table No. 10 showing % distribution of responses to individual items of a remote nature for the various causal components (N = 102)

(a) Cloud Movement

Response* Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		16	14	1	12
2	2	32		21	30
3	11	52	86	78	1
4	44				14
5	12				22
6	31				21

(b) Lightning

Response * Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		5	4	1	22
2		32	1	9	23
3	3	63	95	90	4
4	13				10
5	42				9
6	42				32

(c) Space Movement

Response* Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		16	14	5	12
2	3	26		17	7
3	24	58	86	78	25
4	34				18
5	25				7
6	14				31

* Consult Key to response categories in Figure Nos. 6 - 10

Table No. 10 showing % distribution of responses to individual items of a remote nature for the various causal components (N = 102)

(d) Dreams

Response* Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		13	9	3	19
2	9	26	1	14	32
3	26	61	90	83	6
4	26				7
5	3				5
6	36				31

(e) Night Origin

Response* Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		13	10	9	12
2	10	28	2	1	25
3	8	59	88	90	6
4	4				22
5	42				11
6	36				24

(f) Rain

Response* Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1	1	11	9	2	8
2	7	30	1	13	18
3	19	59	90	85	6
4	27				10
5	6				27
6	40				31

* Consult Key to response categories in Figure Nos. 6 - 10

for media source (mainly T.V.) is examined. Could it be that the citing of television programmes as a source of information may be related to the distribution of 3 and 4 categories? Even the numbers of positive responses to pluralistic, probabilistic and logico-causal components, are relatively high when compared with other remote stimulus items?

Dreams

Responses to the origin of dreams have a sizeable base at category 3 and 4 including some category 2 responses. Such a pattern may be explained in conjunction with the high concentration of responses given to the "self" source of experience. In some cases, the quality of causal explanation and to a lesser extent its analysis, in the other components, may be due to children being asked and able to appreciate causal situations related to themselves.

Origin of Night

The outstanding feature of the responses to this item is the large concentration of category 5 explanations, followed by a somewhat smaller number of "don't knows". On the other hand, the number of category 2 explanations is relatively large for a remote item. This trend is maintained to some extent in the other causal components, with large concentration on the don't know category. The large number of responses citing book sources, may be to some extent responsible for the registration of the high categories in the various components?

Rain Item

The responses recorded for this item, form a step-wise pattern from category 4 to 1. This item was the only one to elicit a category 1 explanation for the initial causal component. At the other extreme, a large number of category 6 responses were recorded, while the pre-causal element is small. There are only modest numbers of + ive responses to the pluralistic and probabilistic components and the + ive number for logico-causal responses are among the least for any item in the whole battery.

A large number of responses were recorded for the school as a source of information. This is not surprising since the rain cycle was one of the topics that was taught to all Ss during the course of the investigation. It is therefore surprising that we have so many 'don't know' categories recorded for all four components.

(c). Malfunctional Stimulus Item (Refer to Tables Nos. 11a - f)

Clock stopping

The number of responses recorded for category 6 or 'don't know' at the initial causal component level, is the highest for any of the mal-functional items (see Table No. 11a). This indicates the difficulty Ss had with this item. The largest number of responses however, were recorded for category 3, which means that many explanations for this item were beginning to show some degree of relational thinking. Relatively high numbers of positive responses were registered for the pluralistic probabi-listic and logico-causal components. High numbers of "familial" and

Table No. 11 showing % distribution of responses to individual items of a malfunctional nature for the various causal components (N = 102)

(a) Clock Stopping

Response* Category	Components				
	Initial	Pluralistic	Probabilistic	Logico-Causal	Experiential
1		40	24	9	26
2	6	22	3	30	36
3	45	38	73	61	1
4	18				9
5	1				4
6	30				24

(b) Glass Breaking

Response* Category	Components				
	Initial	Pluralistic	Probabilistic	Logico-Causal	Experiential
1		49	32	17	23
2	6	26	1	39	43
3	45	25	67	44	8
4	33				5
5	1				10
6	15				11

(c) Train Crashing

Response* Category	Components				
	Initial	Pluralistic	Probabilistic	Logico-Causal	Experiential
1		36	25	10	17
2	7	31	1	30	6
3	44	33	74	60	48
4	29				9
5	2				3
6	18				17

* Consult Key to response categories in Figure Nos. 6 - 10

Table No. 11 showing % distribution of responses to individual items of a malfunctional nature for the various causal components (N = 102)

(d) Death

Response * Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		64	37	20	21
2	4	18	2	45	17
3	21	18	61	35	32
4	59				9
5	1				6
6	15				15

(e) Boat Sinking

Response * Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1	1	41	26	12	21
2	21	31	4	35	16
3	37	28	70	53	33
4	32				17
5					6
6	9				7

(f) Balloon Bursting

Response * Category	Components				
	Initial	Pluralistic	Probabi-listic	Logico-Causal	Experien-tial
1		49	29	9	16
2	11	28	1	42	57
3	40	23	70	49	13
4	38				5
5	1				6
6	10				3

* Consult Key to response categories in Figure Nos. 6 - 10

"self" responses give some indication of the role which these sources play, in the general appreciation of malfunctional causal situations. Clocks being common objects in most homes and are moreover, subject to breakdown, came through in many instances of Ss response to this item.

Glass breaking and Train Crashing

Both items are examples of force and impact being the cause of breaking or crashing. The general patterns of response distribution are fairly similar in both cases for the first four causal components. Category 3, is clearly a feature of causal explanations for these items. The train item, is marginally more difficult than the glass breaking one, as shown by the number of category 6 responses registered for initial causal component; and the much larger number of logico-causal responses (i.e. + ve) registered for the glass breaking item. Another difference, is the high concentration in the number of familial and self responses in the case of glass breaking, and probably contributing to the nature and pattern of causal appreciation for this item generally. Whereas in the train item, media especially T.V. was a dominant source of information.

People Dying

A large number of category 4 responses is a feature of the initial causal component for this item while category 3 tails behind. However, large numbers of +ive responses are recorded for the pluralistic, probabilistic and logico-causal components. From an analysis of the qualitative data, death was an item that provoked in many Ss, several multi-causal responses, yet the level of explanation was descriptive for most Ss. The number of responses registered for the experiential component were concentrated on the media (T.V. and newspapers mainly) and familial sources. What contributions these sources make to the general level of causal appreciation is sceptical, but whatever else the media promotes the level of causal explanation generally is very descriptive as shown by the low numbers of category 2 and 3 explanations.

Boat Sinking

The largest number of category 2 explanations for the malfunctional item are recorded for this item. It is also the only malfunctional item to elicit a category 1 explanation. The number of category 3 and 4 explanation is also large, leaving the remainder registered as "don't knows." Again, large numbers of +ive responses are registered for the other causal components. In comparison to the reverse causal situation of floating, rather than sinking, the negative context clearly stimulates not only more numbers of higher causal explanations, but a greater degree of causal analysis; i.e. higher numbers of +ive responses to the other components.

Balloon Bursting

The trends for this item followed similar patterns to "glass" and "train" items, but a strong emphasis on self as a source, is likely to have an effect on the quality of causal explanation and causal analysis, as represented by the the results for the initial causal component, and the three remaining components.

9.2 Presentation and Discussion of Results of a Factor Analytical Study of Causal Thinking

The presentation and discussion of results in this section, is linked to Guiding Statement 1, which examines the nature of causal thinking in middle school children, and relationships causal thinking may have to other abilities. This section is particularly concerned with research questions 3 and 4 and their associated hypotheses, which provide a direction to what relationships exist (see Chapter 6 for more specific details). The first part of this section, will examine the relationships between individual causal measures, and measures of other abilities, while the second part will examine the way these relationships have grouped themselves as shown by applying factor analysis.

9.2.1 Relationships between individual causal measures and measures of other abilities

The results for this part of the investigation are presented in Table Nos. 12 - 15 in this chapter, and in Appendix D, Table Nos. 1 to 6. The level of significance for a sample size of 102 with 27 variables was taken at the 1% level so that correlation values below .255 were discarded. (see Childs (1970) reproduced from Fischer (1965)). The level of significance for the one way analysis of variance was also taken at the 1% level.

(a) Relationships involving Initial Causal Components Var 007, 008, 009 (Refer to Table No. 12a)

The highest correlations are recorded for the various types of stimulus materials for each of the initial causal components. This indicates a fairly high degree of relationship between these different stimulus materials for this component. The relationship between the initial causal components and the pluralistic component is clearly of a low order judging from the much lower significant correlations, being all around the .3 level. Where there are relationships indicated with the logico-causal component, they are all negative ones. From the above it may be concluded, that the Ss in this investigation showed in the appreciation of causality as measured by the PCTB, initially appreciating a cause is of a different order to that of detecting possible multi-causes, and quite different when it comes to logically explaining probability of causes in a situation.

Throughout all three types of stimulus material, it appears that mathematical problem solving is related to the initial appreciation of causality, although the correlation value for malfunctional causal components is the highest. This may be a feature of the negativity in malfunctional situations. Again the highest correlation for the mathematical concept test was registered for the malfunctional stimulus materials. There is a weak relationship between the ability of children here to appreciate malfunctional causal situations initially, and their performance on tests of mathematical problem solving and concept attainment. Appreciation of familiar material did not correlate significantly with performance on the mathematical concept test.

An interesting result is the negative correlation of the familiar causal components with the water level test. It seems that an initial appreciation of familiar causal situations, in which there are entirely verbal responses to verbal test presentation, differ when a causal situation is a mixture of verbal and demonstrational (motor mainly) cues. The low number of category 2 and 3 explanations, gives a more qualitative picture to this situation. Is it that the demonstrational cues are distracting Ss from giving more qualitative responses? If this

Table No.12a showing list of significant coefficients extracted from the correlation matrix (see Appendix D_{3_1} p<·01)*

Var 007		Var 008		Var 009	
Var	Value	Var	Value	Var	Value
008	.623	007	.623	007	.616
009	.616	009	.492	008	.492
018	.368	018	.342	078	.349
016	.338	030	-.337	018	.345
017	.324	028	-.323	017	.323
028	-.310	053	-.308	077	.301
078	.279	077	.292		
053	-.255	016	.270		
		078	.255		

Table No. 12b*

Var 016		Var 017		Var 018	
Var	Value	Var	Value	Var	Value
007	.338	016	.672	016	.425
017	.672	018	.427	017	.427
018	.425	007	.324	030	-.380
028	-.291	009	.323	007	.368
008	.270	029	-.298	008	.342
				009	.345
				029	-.263

KEY TO VARIABLES

007 PCTB Initial Causal Comp. Familiar
008 " " " " Remote
009 " " " " Mal-functional
016 " Pluralistic Comp. Familiar
017 " " " Remote
018 " " " Mal-functional
028 PCTB Logico-Causal Comp.Familiar
029 " " " " Remote
030 " " " " Mal-functional
053 Causal Demonstration-Water Level Test
077 Richmond Achievement-Maths Concept
078 " " -Maths Problem Solving

* Applies to Table No. 12b

result is at all generalisable to other causal situations using a demonstrational mode, the role of demonstration in influencing explanation and understanding is clearly in need of further investigation. This is especially the case in science teaching where much of it still relies on this mode, to clarify purely verbal explanation.

(b) Relationships involving Causal Pluralistic Components Var 016, 017, 018 (refer to Table No. 12b)

The highest correlations, are those recorded between the pluralistic components from the different stimulus materials. Correlations with the initial components were lower in value for all three types of stimulus material, when compared to those between pluralistic ones. This indicates the apparent separateness of the two types of components, and will be discussed in greater depth in the section concerned with the factor analytical treatments (see page 241-). The correlations of the pluralistic components with the logico-causal ones are negative, which not only means the ability is a separate one when it comes to analysing this conception of causal thinking, but a very different one. The recall and listing of causes which is what causal plurality is about, is clearly different from logically explaining and giving reasons, why one set of causes or cause is the most probable. This appreciation of causal plurality and appreciation of initial causality, are positively related and seem to involve similarities. On the other hand, as shown from the discussion on initial causal components previously, neither appreciation of initial cause or causal plurality have similar features when related to the logico-causal component.

(c) Relationships Involving Logico-Causal Components Var 028, 029 and 030 (refer to Table No. 13a)

Where correlations exist between the logico-causal component and the initial causal component, they are negative, underlying the difference in the appreciation between the two types of components that the Ss show in this study. The negative nature of the correlations met with in the initial causal components appears further in the appreciation of causal plurality. However the logico-causal component in malfunctional stimulus material is positively related logico-causally to the other forms of stimulus material and is further correlated with scepticism although it is a low correlation. Malfunctional material also provides, negative correlations with language usage and mathematical problem solving. This finding differs from the relationship between these language and mathematical measures and initial causal components for malfunctional material. Again, it appears therefore we have a different ability in the appreciation of logico-causal components.

(d) Relationships Involving Causal Demonstration Var 053 (refer to Table No. 13b)

The water level task is a causal demonstration, in which the S observes the E's action in performing the task. The results indicate that significant relationships exist, only between the performance of Ss on initial causal components in which familiar and remote stimulus material form the basis of the verbal test. The other significant correlation is for the language construction test. In the case of the initial causal components, the correlations are negative while that for the language construction test is positive. It appears that when Ss are called upon to explain a causal situation presented verbally, and in which these situations are familiar or remote, a different set of circumstances is provided. The different circumstances being, that a causal demonstration has many motor perceptual cues which may detract the S from responding at a level equivalent to that of a verbal presentation. The implication of this finding if it is generalisable to other forms of demonstration, would have implications for the teaching and learning of science, an issue which will be discussed further (in Chapter 12). Although the positive correlation with language construction test is low, it indicates some relationship that an ability to construct sentences using causal connectives has, in the appreciation of causality through demonstration.

(e) Relationships Involving Sentence Completion and Construction using Causal Connectives Var 056, 057 (refer to Table No. 13b)

Very high correlations are recorded for the performance of Ss on measures of causal reasoning, relational thinking and sentence completion. In many of the questions asked in these tests, completion verbally was always coupled with a demonstrational or purely motor mode in appreciating the nature of causality. The ability to complete causal statements therefore plays an important part in causal explanation as it arises in these tests. However, no significant correlations were registered for the various components of the PCTB. The PCTB is a purely verbal test, and therefore it might be expected that such a test would be highly related, to completion and construction of sentences using causal connectives. The reason for the lack of any significant relationship may lie

Table No. 13a showing list of significant coefficients extracted from the correlation matrix (see Appendix D_{3_1} and D_{3_2} $p<\cdot01$)*

Var 028		Var 029		Var 030	
Var	Value	Var	Value	Var	Value
008	-.323	017	-.288	018	-.380
030	.314	018	-.263	008	-.337
009	-.310	030	.255	073	-.332
016	-.291			078	-.322
				028	.314
				098	.274
				029	.255

Table No. 13b*

Var 053		Var 056		Var 057	
Var	Value	Var	Value	Var	Value
008	-.308	058	.953	056	.592
		096	.922	058	.588
007	-.254	101	.592	096	.581
057	.251	097	.582	101	.566
		098	.422	097	.368
		099	.328	098	.295
		057	.268	053	.255

KEY TO VARIABLES

007 Initial Causal Component Familiar
008 " " " Remote
009 " " " Mal-functional
016 Pluralistic Comp. Familiar
017 " " Remote
018 " " Mal-functional
028 Logico-Causal Familiar
029 " " Remote
030 " " Malfunctional
053 Causal Demonstration - Water Level Test

056 Language Completion
057 " Construction
058 Causal Reasoning
073 Language Usage
078 Maths Problem Solving
096 Relational Test
097 Verification Test
098 Scepticism "
099 Bicycle Drawing
101 Electric Light Problem

* Applies to Table No. 13b

in the practical nature of the relational and causal reasoning tests, emphasizing the use of causal connectives moreso than in the PCTB. The type of language structure required for higher categories of explanation i.e. category 1 and 2, involves more than the ability to complete and construct sentences using words like "became" "as" etc.. A much more sophisticated level of language is required, emphasizing as much non-causal connectives and phrases as causal ones.*

The fairly high correlation with the electric light problem, and sentence completion is again another instance of the ability to use causal connectives in a context of completion, where the causal situation is a very practical one, as in this case. The practical situation, which Ss were confronted with in the electric light problem, was very much a completion situation, and this result is perhaps an expected one. However, there is more than a small element of construction in the electric light problem, yet the correlation with sentence construction is much lower. This could be due to the fact, that the E's presentation of parts of the circuit e.g. battery, wires was more conducive to a "completion mental set" rather than a "construction mental set"?

Measures of verification and scepticism correlated rather higher with sentence completion than with sentence construction. However, taking the correlations for completion and construction, the magnitude of the correlations are smaller than with other measures discussed earlier. This indicates, the lesser importance that completion and construction of sentences using causal connectives has, for expressing verification and scepticism in causal situations.

The correlation between sentence construction and causal demonstration has already been dealt with previously. However, an observation

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* Consult Appendix A_2 - Response Guide for the various items.

which might throw more light on this relationship is that in the demonstration test, E by demonstrating the task, actively constructed the situation before the S. Could it be that a "setting up" factor on the part of E may be accounting for the relationship?

A low correlation for the sentence completion task and the bicycle drawing exercise is not easy to explain, as perhaps the ability to construct a drawing of a causal mechanism might be expected to relate more to the construction of sentences using causal connectives. However, although the initial stages of drawing a bicycle is a highly constructional process completing or "piecing in" the parts is also certainly an essential facet in drawing. So, perhaps sentence completion using causal connectives is a factor in a task where a fair measure of completion is required. Especially a task portraying a causal mechanism through drawing, where the linguistic completion process is internalised as the drawing is executed.

(f) Relationships involving Causal Reasoning, Relational and Electric Light Test Var 058, 096, 101 (Refer to Table Nos. 14a - b, 15)

The very high correlations of causal reasoning, relational thinking with sentence completion has already been discussed previously. The high correlation between causal reasoning and performance on a relational test is predictable, when much of the causal reasoning is so bound up with relational thinking. However, the practical nature of several of the sequences included in the causal reasoning test lend themselves to the observation and analysis of relationships e.g. drawings and positions of objects on such drawings etc. (see Appendix A_4).

The very practical nature of the electric light problem embraces relational thinking, and this is reflected in the correlations between this

Table No. 14a showing list of significant coefficients extracted from the correlation matrix (see Appendix D_{3_2} and D_{3_3} $p < \cdot 01$)*

Var 058		Var 073		Var 077	
Var	Value	Var	Value	Var	Value
056	.953	030	-.332	008	.301
096	.899			009	.292
101	.560				
097	.351				
098	.284				

Table No. 14b*

Var 078		Var 096		Var 097	
Var	Value	Var	Value	Var	Value
009	.349	056	.922	056	.422
030	-.322	058	.899	098	.370
007	.279	057	.581	096	.369
008	.255	101	.553	057	.368
				058	.351
		097	.369		
		098	.342		

KEY TO VARIABLES

007 Initial Causal Comp. Familiar
008 " " " Remote
009 " " " Mal-functional
030 Logico-Causal Malfunctional
056 Language Completion
057 Language Construction
058 Causal Reasoning Test
096 Relational Test
097 Verification Test
098 Scepticism Test
101 Electric Light Problem

* Applies to Table No. 14b

test and the Relational thinking task. Correlations also registered for the language construction and causal reasoning, indicate the role which these abilities have in the solving of a practical causal problem.

(g) Relationships Involving Verification and Scepticism Var 097, 098 (Refer to Table No. 14b)

The two measures of verification and scepticism correlate with language ability, although sentence construction gives the highest correlation. Verification has a higher correlation with the causal reasoning test than does scepticism. This is due probably to the strong judgemental aspect built into many of the examples used in the test. However, the correlation is not that high and the relationship is rather weaker than expected.

On the whole, there were lower correlations for the sceptical measures than for the verification ones, so that the ability to verify is a slightly more important ability to consider in its relationship with causal thinking. Although, the lowest correlation for either measure was registered between scepticism and the logico-causal component for malfunctional situations, and therefore, represents some indication that being sceptical, is related to a negative situation.

(h) Relationship Involving Mathematical Measures Var 077, 078 (Refer to Table Nos. 14a, 14b)

Two mathematical measures involving the appreciation of concepts and problem solving were given as part of the Richmond Achievement Test. For the most part, low correlations were produced; the highest being malfunctional
for the remote initial causal component and the next for the

Table No.15 showing list of significant coefficients extracted from the correlation matrix (see Appendix D_{33} and D_{34}) $p < \cdot 01$

Var 098		Var 099		Var 101	
Var	Value	Var	Value	Var	Value
097	.370	056	.268	056	.582
096	.342	078	-.260	058	.560
056	.328			096	.553
057	.295			057	.320
058	.284				
030	.274				

KEY TO VARIABLES

030 Logio-Causal Malfunctional
056 Language Completion
057 " Construction
058 Causal Reasoning Test
078 Maths Problem Solving
096 Relational Test
097 Verification Test
098 Scepticism
099 Bicycle
101 Electric Light Problem

initial causal component. These results give a weak indication of a mathematical relationship for these two types of material vis-a-vis the initial causal components.

(i) Relationship Involving Measures of Causal Creativity Var 102, 103, 104 (see Appendix D_{34})

Apart from a fairly predictable result for the correlation between construction of sentences using causal connectives and involving a measure of creative imagination, no underlying evidence of a significant relationship exists between causal creativity and the various causal components of the PCTB.

(j) Causal Thinking and Children's Appreciation of Conservational Notions (Refer to Table Nos. 16, 17 and Appendix D_4)

The results of the one-way analysis of variance shows that no significant values at the 1% or 5% levels of significance are recorded for familiar initial causal components for any of the conservational notions. The nearest value being that for volume conservation with substance next. This approaches to some extent the findings of Berzonsky except that the comparison he obtained used a Jöreskog (1966) maximum likelihood method of factor analysis and that the coefficients were just significant at .3 levels. With reference to the responses registered for the remote stimulus material, the F value for volume conservation is significant at the 1% level. This could indicate that formal operational thinking as measured by this Piagetian task, is comparable with the appreciation of causal situations requiring a more imaginative and abstract form of thinking. A "near miss" for this type of initial causal component, was the value registered for the conservation of area approximately .2 below the 5% level of significance. Another "miss" was the conservation of substance. It seems fairly clear that an appreciation of causal situations of a more familiar kind are not linked very significantly, to any of the well tested Piagetian tasks covering concrete to formal operational thinking. On the other hand, appreciation of remote causal situations, appear to be comparable with some of these Piagetian tests, and especially so in the case of volume conservation. Comparisons with malfunctional stimulus material, indicate that the ability to conserve substance is compatable with the appreciation of negative causal contexts. What these results indicate therefore, is that operational thinking as measured by conservational tests, bears overall a rather weak

Table No. 16 showing F values obtained from a comparison of familiar remote and malfunctional initial components with conservational notions ($N = 102$, df 3, 101, $p < .01^{*}$)

	Stimulus Material		
Conservational Notion	Familiar	Remote	Malfunctional
Substance	2.0204	2.2771	4.2536 *
Weight	.2383	1.0981	.4215
Area	1.9254	2.5398	2.2633
Volume	2.1086	3.9073 *	1.8510

comparison to the appreciation of causal thinking in the context of the initial causal components. However where comparisons are fairly definite, they are to be found in instances of causal situations which required a considerable effort on the part of Ss, in explaining them at higher levels of explanation i.e. category 1 and 2. Those Ss who were able to accomplish these explanations, also showed an appreciation of volume conservation. The appreciation of malfunctional situations is only comparable to concrete operations in any significant way. Is it that negative causal contexts for initial causal components are more concrete in the way they are appreciated than the other situations which are familiar or remote in nature?

Table No. 17 Showing F values obtained from a comparison of familiar, remote, malfunctional logico-causal components with conservational notions ($N = 102$, df 3, 101, $p < .01^*$)

	Stimulus Material		
Conservational Notions	Familiar	Remote	Malfunctional
Substance	2.344	2.280	4.2489 *
Weight	2.290	.667	1.4947
Area	1.761	1.0922	1.1069
Volume	5.786 *	1.5299	4.4106 *

The results in Table No. 17 show that comparisons between conservational measures and the logico-causal component, indicates more significant F values than for the initial causal component. This is to some extent an expected outcome, if the Piagetian position of some interrelationship existing between operational and causal thinking is considered. However the level of significance although high, for some notions is patchy and so one may conclude, that the relationship is not that strong. The case of malfunctional causal situations once again arouses interest in that significant F values were registered for both substance and volume conservation. Clearly, the nature of malfunctional contexts promotes interesting developmental patterns and is an area that should receive further research, for it could have implications not only for developmental psychology but for educational practice as well.

From these findings it may be concluded that the relationship between operational thinking as measured by the four tests of conservation and causal thinking as measured by two components of the PCTB is not as close as Piaget and de Garcia (1976) would have one believe. It appears, that substance and volume provide the strongest case for any comparison and are at fairly high levels of significance. This seems to indicate that operational thinking provides only a partial answer to the mechanisms involved in the development of causal thinking. Furthermore, the relationship between operational thinking and causal thinking appears to be a function of the context of a causal situation. Malfunctional causal contexts for both initial and logico-causal components can clearly bring in to play fairly significantly, concrete and formal operational levels of thinking.

9.2.2 Group Relationships and the Application of Factor Analysis

The results that are presented and discussed in this section are to be found in Table No. 18, Figure No. 11 and Appendix D_5 and D_6. The level of significance for correlation coefficients was taken as .255 to .304 which is in line with the Burt-Banks Formula (1947) and quoted in Childs (1970). These significance levels apply to both Principal Factor Analysis and the Varimax Rotation.

The criteria for the number of factors to be extracted follow the Kaiser's criterion; i.e. factors only having latent roots or eigenvalues greater than 1 will be considered.

(a) Principal Factor Analysis (Refer to Appendix D_{5_1} and D_{5_2})

Only a brief discussion will be given under this section, as the varimax rotation gives a much clearer view of the relationship between the groups of variables that cluster in one part or another of the Factor Matrix. However, examination of Appendix D_{5_1} indicates that seven factors emerge with eigenvalues above 1. Factor I has a strong emphasis in ability as measured by Richmond Achievement Tests but with some clustering of initial causal components. Factor 2 is clearly a causal factor for the highest correlations load on the causal measures such as the initial causal components, and the causal reasoning tests. A high correlation for completing sentences with causal connectives indicates the importance that language of this form has in appreciation and therefore explanation of causal situations.

Factor 3 indicates a spatial and demonstrational flavour in that the highest correlations are loaded on the tests of a spatial and referential nature in the Richmond test. Fairly high correlations are also given for the causal reasoning and water level test, both measures involved with considerable spatial and psychomotor activity. The negative correlations given by the initial causal and pluralistic components show that the strong verbal nature of these measures reflects, the difference which exist when children are presented with purely verbal stimuli. This is contrary to situations that Ss meet in the causal reasoning and water level tests, which explore modes other than solely linguistic ones in the way children explain causal phenomena.

Factor 4 has a high loading on the causal creativity measures especially the fluency one. This indicates a strong causal creativity flavour to this factor. However it can be noted that the whole set of coefficients for these measures of creativity are clustered together and appear to be a separate ability, from general measures of ability and causal thinking as measured by PCTB and other causal reasoning tests.

Factors 5, 6 and 7. These have eigenvalues of 1.51367, 1.2099 and 1.13937 respectively and account for only 14.2% of the variance. Scrutiny of the correlation coefficients and the lack of any meaningful clustering suggests that these factors are of limited value, and merit no further discussion.

From the Principal factor analysis therefore only 4 factors emerge having any consequence. Factor I has a strong element of ability as measured by a standardised achievement test. Factor 2 has high loading on measures of causal thinking and is clearly a causal reasoning factor. Factor 3 indicates by virtue of the loadings on tests of spatial and psychomotor ability in both causal and non-causal contexts, that a psychomotor element is a feature of the variance. Finally Factor 4 has high loadings on measures of causal creativity, indicating the role creative thinking plays in some forms of causal appreciation. Factors 5, 6, 7 are however generally rather different, from which little of value can be extrapolated. However while Factors 1, 2 and 3 gave more definite trends the coefficient values for the most part were of a moderate order none going beyond 0.6. These moderate values tended to give a picture of a merging of abilities, which were not indicated by the results obtained in the inter-correlation matrix. So it was decided to treat the inter-correlation matrix with a Varimax Rotational Solution, the results of which will form the subject of the remainder of this chapter.

(b) Varimax Rotation of Factor Matrix (Refer to Table No. 18 and in Appendix D_{6_1} and D_{6_2})

Five factors are extracted having eigenvalues above 1 and accounting for 91.7% of the variance (see Table No. 18 and Appendix D_{6_1}). Therefore the main discussion will refer to these 5 factors.

Factor 1

Three clusters of correlations are to be found in this factor, the first cluster includes three very high correlations for sentence completion using causal connectives, for the causal reasoning and relational tests. There is clearly, a very strong relationship between being able to complete sentences with various causal connectives, to appreciate relationships, and to explain several causal situations, some of which were very practical for the Ss. The second cluster, include loadings on construction of sentences, using causal connectives and the causal problem solving task - the electric light. Once again, an ability to construct sentences using causal connectives is related to the solving of a practical causal problem.

A third cluster of coefficients include verification and scepticism measures. It is clear that abilities to judge situations are important, when it comes to weighing up various causal phenomena, and according to the loadings included in this factor such abilities are related to very practical causal contexts. Such a context is a marked feature of the electric light problem and a somewhat lesser one for the causal reasoning tests, where a mixture of purely verbal and practical modes were used.

The work of Berzonsky (1969) is the only research that can be compared with the results of this investigation and this can only be done very tentatively. In no way, was the present investigation a replication study of Berzonsky's work, for there are many differences in the structure of the tests and also in the inclusion of several different measures. How-

Table No. 18 Showing Varimax Rotation of Factor Pattern

Variables	Factors*				
	1	2	3	4	5
PCTB Initial Causal Component Familiar				.773	
" " " " Remote				.588	
" " " " Malfunctional				.699	
" Pluralistic Component Familiar					.773
" " " Remote					.815
" " " Malfunctional				.299	.417
Causal Connectives - Completion	.984				
" " Construction	.602				
" Reasoning	.952				
Richmond Test - Language Usage		.683			
" " Mapping		.775			
" " Graphs		.739			
" " Reference		.775			
" " Maths Concepts		.802			
" " Problem Solving		.793		.274	
Relational Tests	.939				
Verification	.421				.259
Scepticism	.370				
Causal Problem - Electric Light	.580				
" Creativity - Fluency			.991		
" " Flexibility			.803		
" " Originality			.842		
% Variance	30.5	23.9	16.5	14.1	6.8
eigenvalues	4.96830	3.88780	2.67992	2.28830	1.10165

* Coefficients below .255 omitted

$p < \cdot 01$

ever comments can be made regarding some parallels and also differences during the discussion of the various factors. In factor 1, language ability is clearly an important feature, as is chance and incongruity subsumed in this investigation under causal reasoning. Scepticism too loaded on Berzonsky's first Factor. However, a crucial difference concerns the fact that no significant correlations were recorded in this factor for any of the components of the Physical Causality Battery in this investigation. However, it must be noted that Berzonsky's measure for causal thinking at the three stimulus material levels is a crude one. It may be, that had he contrived a more sensitive measure as in this investigation i.e. four categories of naturalistic explanation, the loadings might well have been different. Verification was not a feature of Berzonsky's factor 1 this in fact does not emerge until factor 3 in his findings. As stated earlier the inclusion of a practical causal problem test like the electric light one, which requires a certain amount of judgemental ability may be an important influence here in structuring this aspect of Factor 1. Therefore factor 1 has a very strong element of linguistic - relational - causal problem solving components which are clearly related to practical causal situations bringing into play a certain degree of judgemental (verification) and sceptical ability.

Factor 2

There is a very distinct clustering of the measures of achievement from the Richmond Test. Particularly high correlation coefficients are registered for mathematical conceptual, and mathematical problem solving measures. Relational measures are also well represented as shown by the high correlations on reference and map reading - both abilities relying substantially on spatial appreciation. Ability to interpret graphs and to use language in a general context, reinforces the earlier findings in the last section on correlations between individual variables. The only comparison that can be made with other research findings is with the study of Berzonsky and here IQ measures were used instead of achievement tests. The raw scores of the IQ measure loaded on factor 1 but it was not a very large coefficient.

However, no meaningful comparison can be made in view of the nature of the measure and the amount of measures used in this analysis. Clearly then, achievement scores reflecting several types of ability particularly mathematical have an important role in the mental structure and processes of causal thinking, but such abilities are distinctly highly clustered vis-a-vis causal, and other non-causal measures.

Factor 3

A cluster of three very high correlations for causal creativity, indicates a fairly strong creative element in the appreciation of causal situations. The highest correlation on fluency raises the crucial role of language in the appreciation, of causality and an almost "near hit" (see Appendix D_{6_1}) with the variable for language construction using causal connectives was produced. The language construction test, demands a considerable amount of "creative strength" as well as fluency in contriving causal situations, so it is not unexpected to have a positive relationship with this variable.

It appears therefore, that causal thinking as it is investigated in this study has a certain creative element to it, however it is not possible to compare these findings with any other comparable study and therefore one cannot proclaim any general statements vis-a-vis the external validity of this factor. However, if it does have any generality it may be useful for teachers of science, to develop programmes that take into account the creative nature of causal thinking, so that an overall understanding of the notion can be attained.

Factor 4

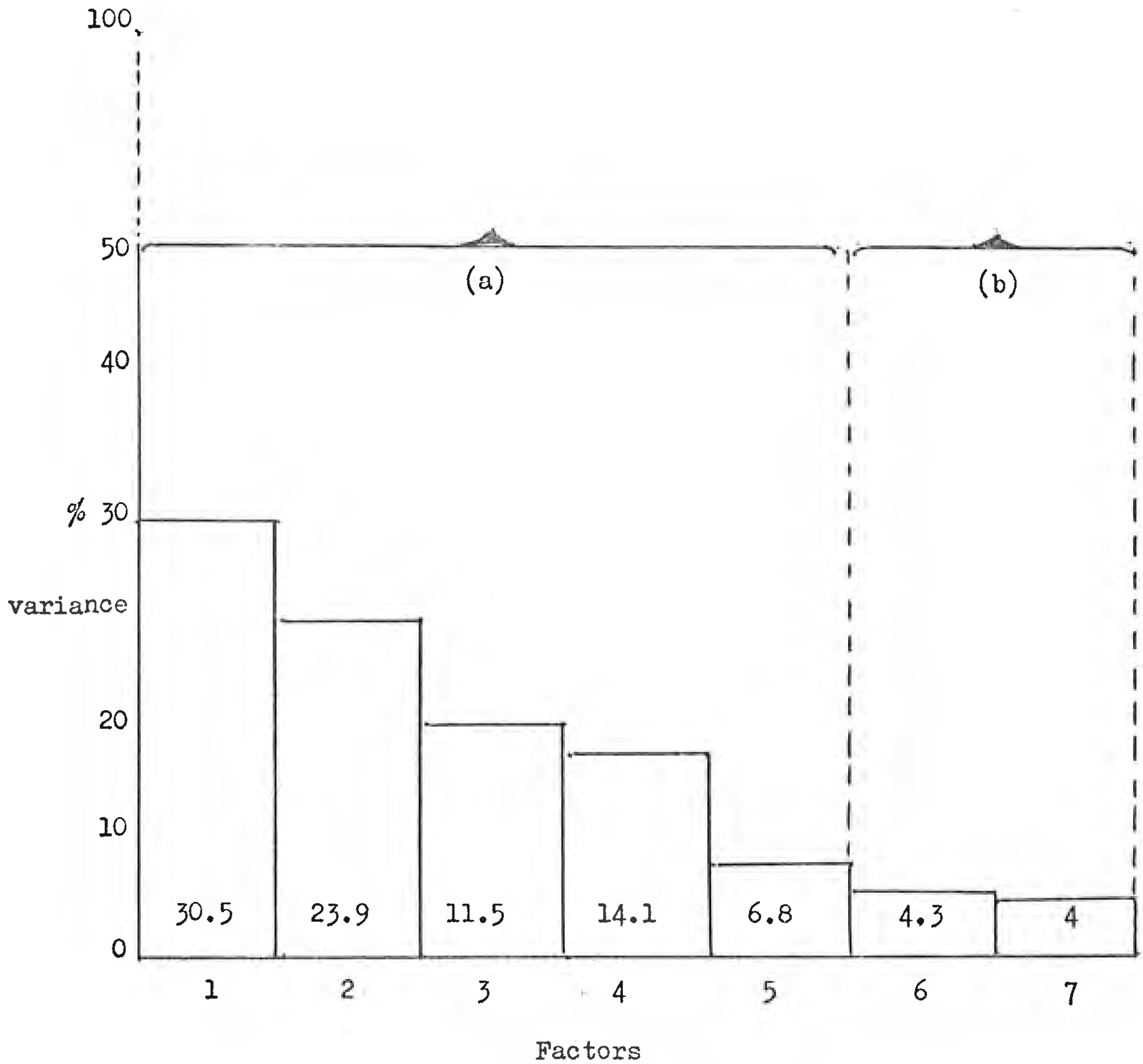
This factor is characterised by fairly high correlations for the initial causal component. In fact, all three types of stimulus material cluster together giving this factor a distinctively causal flavour. However, this factor accounts for only 14.1% of the variance and is roughly of the same order as factor 3, at 16.5%. The ability of appreciating an initial causal situation is fairly important in the general process of causal thinking, nevertheless this ability is not as dominant as the mosaic represented by factor 1 in which verbal, demonstrational as well as relational modes are responsible for the make up of causal thinking. The purely verbal mode of factor 4 is but one way through which causal thinking may be appreciated.

Other correlations making up this factor, but having lower coefficients include malfunctional causal plurality and mathematical problem solving. The coefficient for mathematical conceptualisation is a near miss at .242. These lower clusters of coefficients, indicate a mathematical strain in this factor, with some pluralistic components in a malfunctional context. However, the factor is clearly one which can be seen as having distinctly initial causal features.

Factor 5

The significant correlations for the pluralistic components of all three stimulus materials, gives a definite pluralistic feature to this factor. The coefficients for familiar and remote material are partic-

Figure No.11 Graph showing % Variance for seven factors extracted by a Varimax Rotation



Key

(a) Includes Factors having eigenvalues greater than 1

(b) " " " " less " 1

Factor 1 Linguistic Causal Relationships
" 2 General Achievement
" 3 Causal Creativity
" 4 Initial Causal Component
" 5 Causal Plurality
" 6) discounted
" 7)

ularly high, and both are causal situations included in positive contexts, as opposed to the malfunctional negative context. This difference may be a contributory influence? The % variance for this factor is only 6.8, indicating the relatively small part it plays in causal appreciation. However, causal plurality does seem to enter into a general picture of causal thinking as investigated in this study, and causal plurality linked to familiar and remote levels of experience are of particular importance.

The "near miss" of the coefficient for the verification measure, illustrates a tenuous connection between appreciation of causal plurality and judgemental ability. The late arrival of the appreciation and analysis of causal situation through a verbal mode in the form of Factors 4 and 5, indicates that the children studied here operate less effectively at an abstract level.

(c) General Conclusions

Figure No. 11 shows the % variance exhibited by the seven factors extracted from the correlation material using the Varimax Rotation. Factor 1 loads very highly on linguistic - causal reasoning and relational measures and this factor we may call a Linguistic-Causal Relational Factor. Factor 2 loads fairly high on all components of the Richmond Achievement test; this factor therefore may be labelled a General Achievement Factor. Factor 3 is clearly a Causal Creativity Factor, Factor 4 an Initial Causal component factor and Factor 5 a Causal Plurality factor.

If Factor 6* were to be considered as an extractable entity this would complete the picture as the Logico-Causal Appreciation Factor.

Factors 1 - 2 emphasize Linguistic, Relational and General Achievement, while, Factors 3 - 6 are distinctively Causal but in the verbal mode.

The implications and further discussion of these findings will form the basis for Chapters 11 and 12.

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* see Appendix D_{6_1}

CHAPTER 10

STATEMENT, TREATMENT AND DISCUSSION OF THE LONGITUDINAL DATA

CHAPTER 10

STATEMENT, TREATMENT AND DISCUSSION OF THE LONGITUDINAL DATA

INTRODUCTION

The primary data concerned with the results that are to be discussed in this chapter can be found in Appendix H. In what follows, the results related to research questions and hypotheses emanating from Guiding Statement 2 will be presented. Guiding Statement 2 is as follows: "To select patterns of causal thinking exhibited by first year middle school children, and to examine what changes if any, take place over time".

The research problems and their related hypotheses are to be found in Chapter 6 and will be discussed at length in Chapter 11. However, only the results of the initial causal component of the PCTB will be presented in detail.

The chapter will be divided as follows:

10.1 The Structure and Nature of a three Test Longitudinal Design and Causal Thinking.

10.2 A Global Analysis of the Longitudinal Data.

10.3 Modal Pattern Analysis. (MPA)

10.4 Case Studies of Selected Items.

10.5 Case Studies of Individual Children.

10.1 The Structure and Nature of a three Test Longitudinal Design and Causal Thinking.

Before examining the results for the longitudinal study, it is necessary to clarify and establish key terms and the nature of the processes they describe. This will be done as follows:

10.1.1 Terminology and Structure

10.1.2 The Nature of Modal Patterns

The reader is referred to Chapter 8, Appendix A_1 and A_2 for details of PCTB structure and scoring.

10.1.1 Terminology and Structure

(a) The term Modal Pattern refers to the direction to which change or no change was recorded by a S. There are four modal patterns:

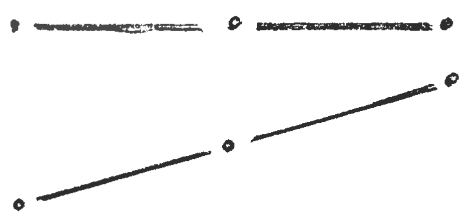
1) Linear, indicating no change in the quality of a S's explanatory behaviour.

2) Progressive, indicating an improvement in the quality of a S's explanatory behaviour.

3) Regressive, indicating a decrease in the quality of a S's explanatory behaviour.

4) Erratic, indicating fluctuations in the quality of a S's explanatory behaviour.

(b) The term Modal Figure refers to the diagrammatic representation of a modal pattern in a generalised form e.g.



Linear figure

Progressive figure

. = test occasion

(c) The term Pattern Type refers to the detailed composition of a modal pattern derived from a 3-test longitudinal design e.g. 4 - 4 - 4 a linear pattern type, or 4 - 3 - 2, a progressive pattern type.

The structure therefore, of modal patterns are derived from the performance of a S as measured by 6 category explanatory system over 3 testings.

In the case of control subjects, all patterns except erratic are possible.

Figure No. 12, shows 13 of a maximum 18 types of modal pattern that emerge when a 6 category scoring system is applied on three discrete occasions. To avoid the unnecessary incorporation of trivial modes, (as this would present an over complicated picture of behaviour) only 13 patterns are given in Figure No. 12.

Each of the patterns will now be briefly discussed in relationship to the study of causal explanatory behaviour.

10.1.2 The Nature of Modal Patterns

a) Linear Patterns

These are patterns that show no change has taken place over the 14 month period in a S's explanatory behaviour. There is neither an increase or decrease in the quality of a child's explanation. Of course, the higher the categories making up the pattern, the more difficult it is to show an increase in quality, and in the case of a 1 - 1 - 1 pattern type there is little more the S can do in improving his explanatory performance. The reiteration of the same category of explanation over

Figure No. 12 Showing possible Modal Patterns for a 3-test longitudinal design (see also next page)

(a) Linear

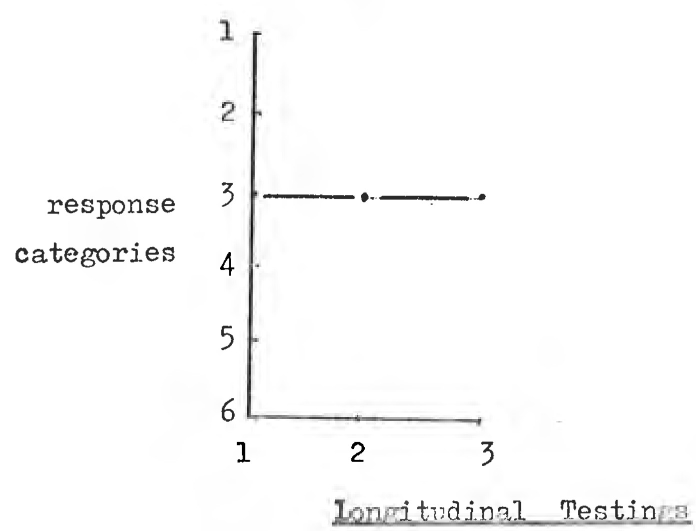
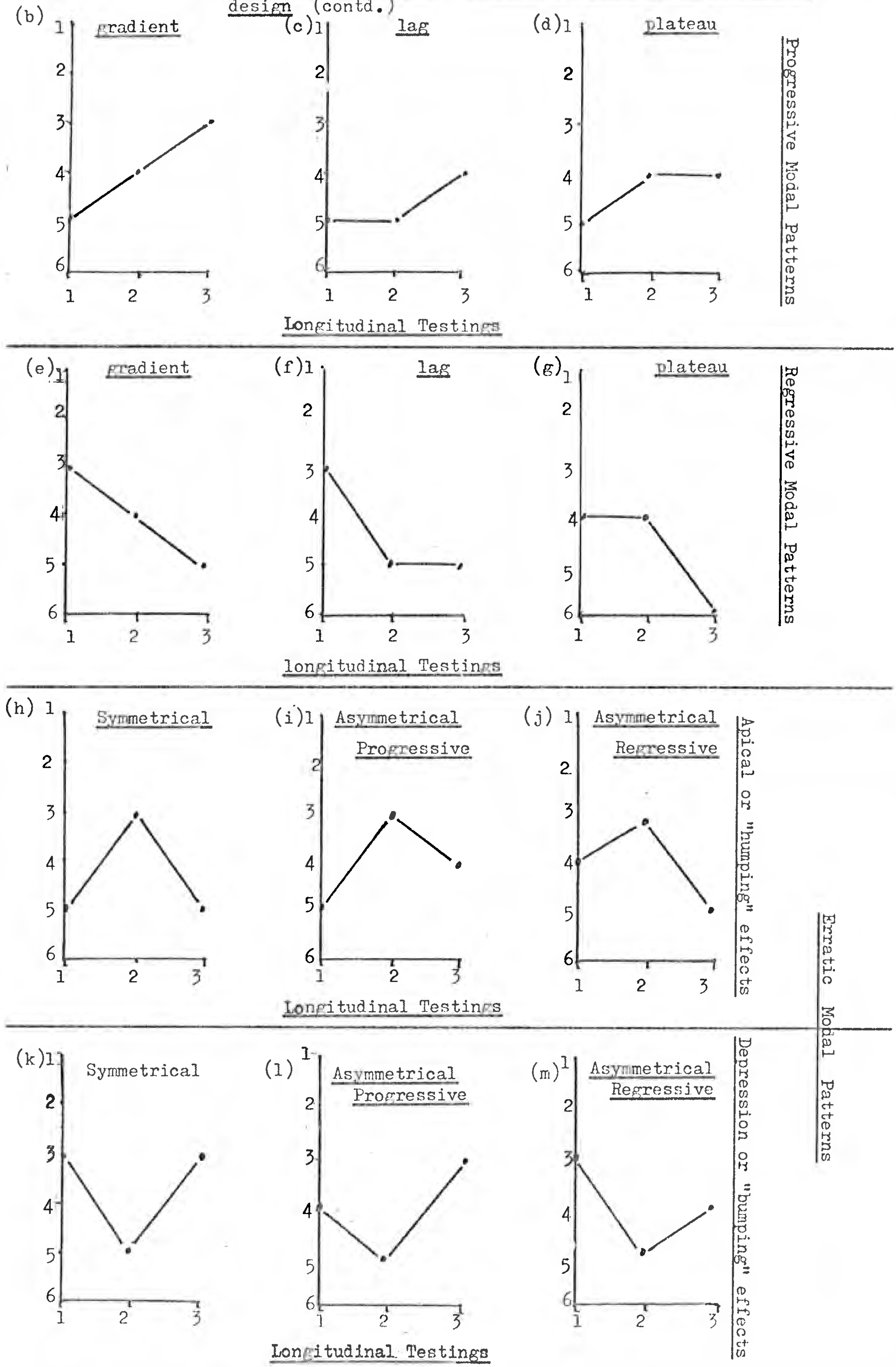


Figure No. 12 Showing possible modal patterns for a 3-Test longitudinal design (contd.)



14 months, can be taken as a strong indication of the level of attainment, or the level of competency a S has reached for a particular item and for a particular time span.

(b) Progressive Patterns

These are patterns of change in which the quality of explanatory behaviour increases either in a gradual stepwise manner, and is thus called a gradient, e.g. 4 - 3 - 2, or where the same explanatory categories are followed by a higher one e.g. 4 - 4 - 3, and is called a lag. Finally, where a progressive pattern of change is marked by an increase and is sustained on the second and third testings e.g. 3 - 2 - 2 this is termed a plateau.

A gradient represents perhaps the ideal developmental sequence, in that it indicates a gradual progression. A lag indicates a slower process in the acquisition of a higher explanatory category. It may be that a lag represents an example of consolidation early on in the observational period. A plateau is a rapid form of progressive change, which indicates a change to a higher category during the second testing, and is sustained at this category on the subsequent testing.

(c) Regressive Patterns

Regressions are not unlike progressions, in that they exhibit the same type of movements but in the opposite direction; a direction which terminates in an explanation being registered at a lower level than the first testing.

Regressive gradients show a gradual regression from a higher explanatory level to a lower one, over 14 months following a smooth or almost smooth path. It is the most unlikely to encounter in the Piagetian paradigm, with its emphasis on hierarchical progression. Regressive lags are rapid forms of regression, and perhaps represent a truer picture of a S's explanatory behaviour. The higher explanatory level on the first testing, could be registered on a day the S had just got to know about a certain causal situation, but had not fully consolidated it. This non-consolidation being borne out by the lower level of explanation, and recorded for the subsequent 2nd and 3rd testings. However, the possibility of experimental error on the part of observers cannot be ruled out as a contributory factor. Regressive plateaus indicate the slowest form of regression, and a difficult one to account for, in that after an apparent consolidation of a category on two separate occasions, a dip to a lower form eventually occurs.

(d) Erratic Patterns

These patterns fall into two main groups, those in which the second testing provides the highest category of explanation, giving an "apical" or "humping" effect, and those in which the second testing provides the lowest category explanation of the three testings. This latter situation leads to a "bumping" or depression effect. Each of the two groups, may be further subdivided into three, a symmetrical pattern, on which 1st and 3rd test occasions, the same explanatory category is registered. The other two, are progressive asymmetrical or regressive asymmetrical patterns. In the former, the third testing shows a higher category of explanation than the first testing, and in the latter, the third testing is of a lower order than the first testing.

All forms of erratic patterning behaviour, show that the Ss on their second testing do not maintain their 1st or 3rd test status in the case of symmetrical patterns. In the case of asymmetrical erratic patterning between a 1st and 2nd status, there is either a high point (in progressions), or a low point (in regressions) which interrupts the developmental sequence. The high point not being consolidated by the end of the 14 months testing; the low point being raised by the end of the 14 month period.

Erratic patterns shed doubt on the validity of assessing Ss on pre and post test statuses, as there is no evidence of any fluctuation if one uses this type of design. By obtaining evidence of a fluctuation, we have a picture of the degree to which a S has consolidated the level of causal appreciation, in this case as measured by a 6 category system. The fact that a S shows evidence of his appreciation of causal situations in an erratic fashion, may have implications for drawing developmental, educational and methodological conclusions; points that will be raised later on in Chapter 11 and 12.

10.2 A Global Analysis of the Longitudinal Data

This section is divided into two :

10.2.1 Descriptive Statistical Item Analysis

10.2.2 Treatment of the Data using a Two Way Anova Mixed Design.

10.2.1 Descriptive Statistical Item Analysis

Figure Nos. 13, 13a, 14, 14a, 15, 15a contain the % number of Ss for both Experimental and control groups that showed the various modal patterns for each item. The discussion of the items will take place under the three main stimulus material types, and within these types various items may be discussed together, if they exhibit some common trend, or simply if some unique feature emerged. Results for the experimental group will form the major part of the discussions that follow.

(a) Familiar Stimulus Material (refer to Figure Nos. 13 and 13a)

(i) Motor Car and Bicycle Mechanism (see Figure Nos. 13a,13a/a,13e,13a/e)

The results for these two items show that the highest number of Ss registered some type of progressive change, also the number of Ss registering a linear pattern came next and were amongst the highest values for all the six familiar items. In the case of the car, the amount of regression recorded was very small but more for the bicycle mechanism. Again, both items show that the number of Ss giving some type of erratic change were about equal. Both items represent examples of causal situations which are very common to children, and this may account for the high numbers of Ss giving progression and linear patterns to their explanatory behaviour. The high level of progression, indicates a capacity on the part of Ss to improve. On the other hand, the high numbers of Ss registering linear patterns, show that there is a fair bulk of Ss who maintain what they already know, but do not show any further indication of an improvement in the quality of their causal explanation.

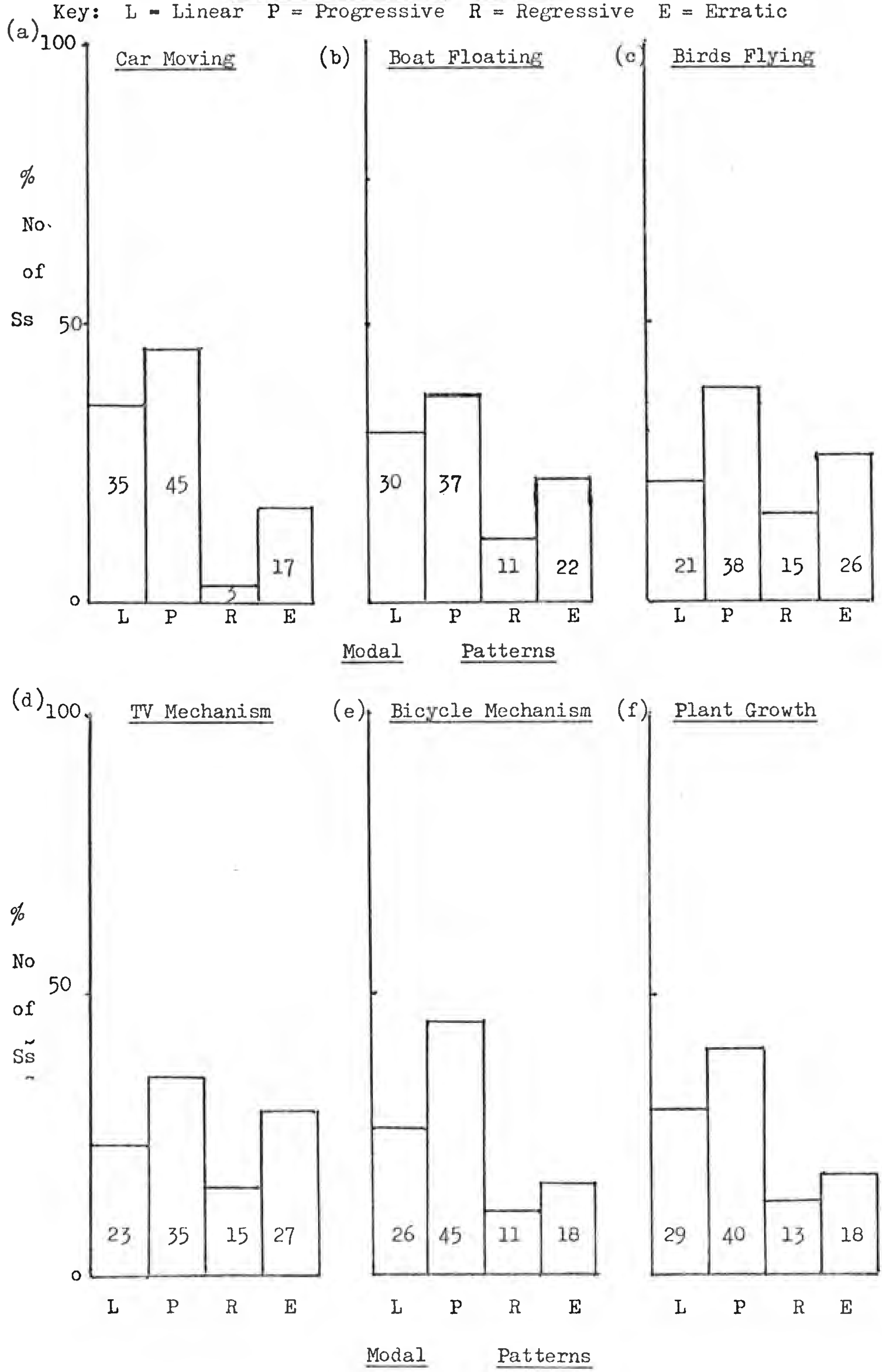
The difference between the two items in the number of Ss exhibiting regression, may be due to an over-familiarity of the bicycle mechanism, so that on subsequent testing the explanations lose their quality. However, a fuller discussion on regression phenomena and on the bicycle mechanism item, will appear in later sections (see 10.3, 10.4 respectively). The results of the control Ss for these items, show similar trends to those of the Experimental Ss, indicating that practice is not such a crucial factor in progression for these items.

(ii) Boat floating (see Figure Nos. 13b, 13a/b)

The results for this item follow fairly closely those for the bicycle

Figure No.13 Showing % No. of Ss registering modal patterns for individual items - Familiar Stimulus Material - Experimental Group (N = 80)

Key: L = Linear P = Progressive R = Regressive E = Erratic



mechanism, but with somewhat less numbers of Ss registering progressive patterns, and more showing linear ones. In comparison to the obverse situation i.e. the sinking of boats (see Figure 15), more progression was registered, and at the same time more regressions too. This may possibly be a function of the difference between a positive and a negative context and will be considered in the discussion on case study items (see 10.4). The somewhat larger numbers showing progressions in the Experimental group as compared to the Control indicate, that a more obvious practice effect may be operating here than in the case for other items e.g. Plant growth.

(iii) Bird flight and TV mechanism (see Figure Nos.13c,13a/c,13d,13a/d)

The results for these items show fairly similar trends, and are both items in which the % of Ss who register regression are the same, and the largest of all the familiar items. The number of Ss registering erratic change is also large for these items, and coupled with the trends in regression, indicate a fair measure of instability in the way these Ss are able to explain these particular causal situations. Clearly, such situations present Ss with a greater degree of indecision and this may be, that after an initial ability to answer what seems a familiar phenomenon; later probing reveals the difficulty of really explaining the rather inaccessibility of bird flight and the workings of a television set. The factor of accessibility, i.e. ability to touch, see at close quarters, simplicity in the workings of phenomenon etc. is an important one to consider, for it may be playing an important role in the appreciation of causal thinking. The fact that children are more often than not in a position to see the actual workings of a car, can monitor plant growth etc. enhances the crucial relational nature which, (from the results of the first part of this investigation and other workers' findings) is such an integral part of causal thinking. In examining the results of the control Ss, a practice effect is operating at a reasonable level for the bird flight and especially for the TV item.

(iv) Plant Growth (see Figure Nos. 13f, 13a/f)

The number of Ss registering erratic and regressive patterns are not that different than for other items, but somewhat more Ss gave linear and progressive trends, when compared to the other example of a living organism i.e. a bird. The point made above concerning accessibility or a degree of familiarity may be reiterated here, for the opportunity of observing change in plant growth is easier to accomplish than with the rather intangible nature of flight mechanism. Bird flight is for most children a daily occurrence that can be observed, but mostly intangible, while plant growth is a less active process to observe on a single occasion but easier to monitor over time by using a ruler to measure activity. Therefore the nature of familiarity may be a crucial factor in the way children appreciate causal mechanisms. Linked with the nature of familiarity, is the effect which experiential variables such as familial source may be having. This has already received some attention in Chapter 9 section 9.1.

The results of the control group, show that when the numbers of Ss showing progressive patterns are compared to the Experimental group; practice appears to have little influence on the appreciation of this causal phenomenon.

(b) Remote Stimulus Material (Refer to Figure Nos. 14, 14a)

(i) Cloud Movement (See Figure Nos. 14a, 14a/b).

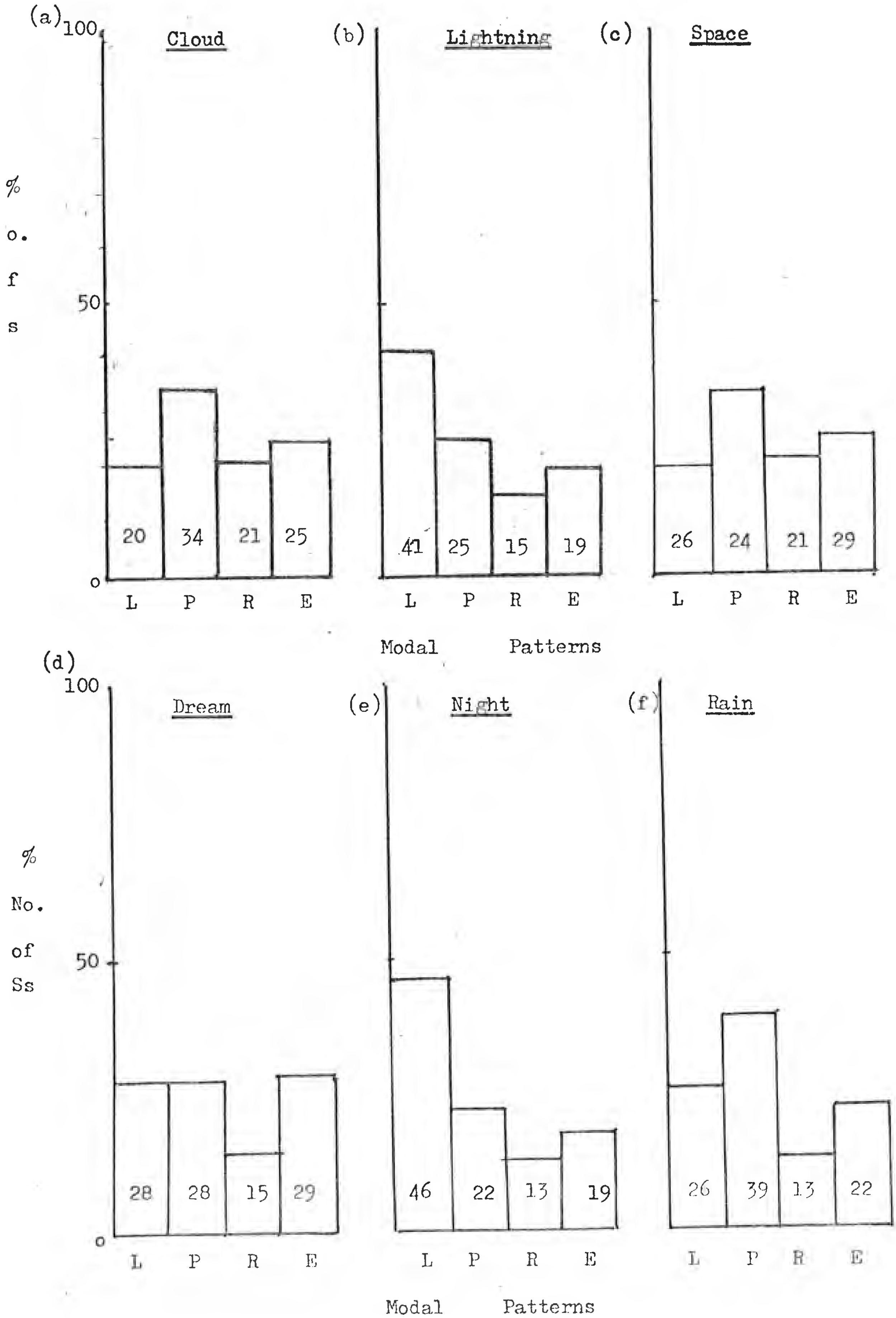
Apart from the distribution of Ss for the progressive patterns which is the highest for this item the number of Ss registering the other patterns are more or less equally distributed. The number of Ss giving regressive patterns together with those giving erratics, indicates the indecisive nature by which Ss responded to this item. However over a third of the Ss gave some form of progression and after the rain item, ranks amongst the highest of the remote stimulus material items in this regard. This is probably related to the fact that as rain is a taught item in this study, and that it is intimately related to cloud movement, an interaction effect is probably operating. Further reference to the regression patterns will be made in more detail in section 10.3. The results of the control group appear to indicate that practice is not having a very marked effect in S's appreciation of this causal situation.

(ii) Lightning (See Figure Nos. 14b, 14a/b).

The results show that apart from night more Ss registered linear patterns than for any item in the remote or other stimulus material for the experimental group. Reference to Appendix E_{3f} shows the pattern types where the particular categories are concentrated e.g. 5 and 6. The more detailed results indicate strongly, the difficult nature of this item and moreover regressive and erratic patterns together account for just under a third, reinforcing further, the difficulty and the pattern of either "no change", regression or "indecisive change" associated with this item.

Figure No.14 Showing % No. of Ss registering Modal Patterns for individual items - Remote Stimulus Material - Experimental Group (N = 80)

Key: L = Linear P = Progressive R = Regressive E = Erratic



However, the origin of lightning is for the majority of Ss a "no change affair" and an affair that is concentrated around successive "don't knows" (Category 6s) "non-naturalistic" (Category 5s) and "one-or two word" (Category 4s) responses. Lightning will be considered later in the section on case study items section 10.4.3.

Space (See Figure Nos. 14c, 14a/c)

The results for this item show that Ss were fairly equally distributed amongst the various patterns, with one of the lowest numbers recording progressive change. An interesting feature, is the similarity in the numbers of Ss registering linear as compared to erratic patterns, which may be thought of as at opposite ends of a continuum; the linear or "no change" and, the erratic or "excessive change". This is to some extent a function of sex differences, where many more females registered linear patterns than males, and more males registered erratic patterns than females (see Appendix E_{31}). Together with the cloud item the number of Ss registering regression, is the highest for any item and is probably a function of the degree of inaccessibility associated with this phenomena.

(iii) Dream (See Figure Nos. 14d, 14a/d)

From a global view, the results of the dream item indicate a fairly equable distribution of patterns, and in some ways resemble the trends met with in the results for cloud and space. However, reference to Appendix E_{31} shows the tremendous diversity within each type of modal pattern for this item. Some reference to these types will be made in section 10.3. In examining the results for the control Ss, practice effects are minimal for the appreciation of the causal nature of this item.

(iv) Night (See Figure Nos. 14c, 14a/e)

The dominant feature of the results for this item is that more Ss gave linear patterns than for any other. This like the lightning item, is obviously for most of the Ss a "no change" item. Reference in Appendix E_{30} shows where Ss concentrated their pattern types, and the majority were 5 - 5 - 5 and 6 - 6 - 6. These pattern types indicate the difficulty which this item presents to Ss. The relatively low number of Ss registering progressive and erratic change, indicates yet another example of an item to which Ss respond, by not changing their appreciation of a causal situation, be it pre-causal, or as in the case of the males (see Appendix E_{30}) a high quality level explanation. The control Ss appear also, to bear out the results for the experimental group in that progression is much lower than linearity, indicating that the effect of practice is small.

(v) Rain (See Figure Nos. 14f, 14a/f)

The results indicate the largest number of Ss giving progressive patterns for Remote stimulus material. The results are probably due to several factors these being (a) origin of rain was taught specifically as part of the rain cycle* in science lessons, (b) rain and its origin appears as a test item in the causal reasoning test (see Appendix A_4), (c) that the rain cycle is linked to cloud movements and both topics appear in the PCTB. These influences are probably having inter-active effects, each item reinforcing the other and thereby affecting the progression of explanation.

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* See Appendix A_2, A_4 Figure 19, reflecting the gist of some of the teaching this sample received for this item.

In view of the above conditions surrounding this item, it was decided to examine further the results associated with rain, as an item case study in section 10.4.3.

The results of the control group show fairly similar trends to those of the experimental group, indicating that practice is only a minor factor in the appreciation of the origin of rain.

(c) Malfunctional Stimulus Material (Refer to Figure Nos. 15, 15a)

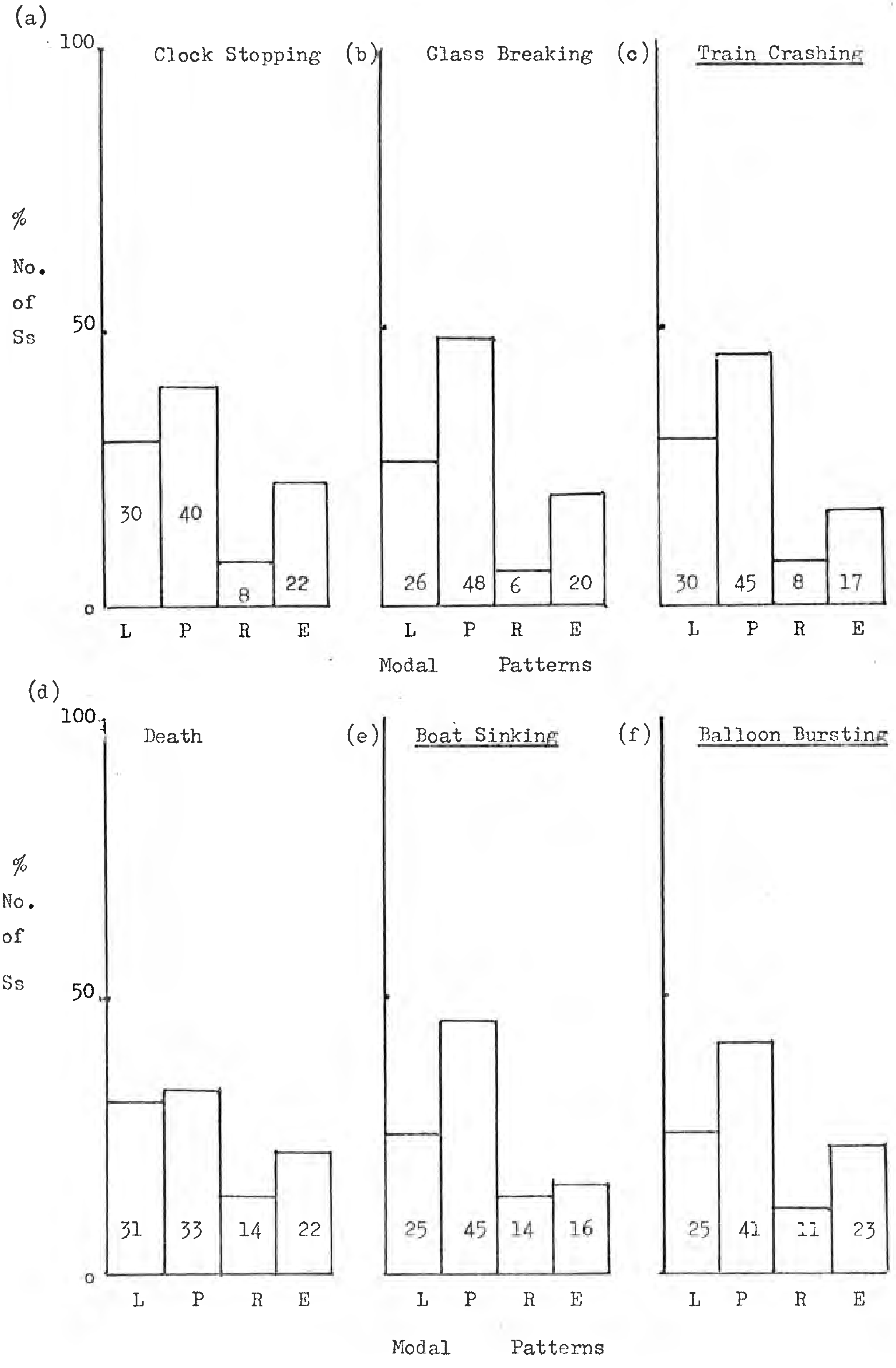
A common thread running through the six items in this group of stimulus material, is that two thirds to three quarters of Ss registered between them Linear and Progressive patterns of causal explanation, the highest % of Ss always registering a progression. From this, it may be concluded that malfunctional causal situations enable Ss either the capacity to improve or consolidate their causal explanation over 14 months. This trend is also borne out by the results from the control group.

(i) Clock Stopping, Glass Breaking and Train Crashing

The results for all three items show that globally, the number of Ss registering Regressive and Erratic Patterns are roughly the same, with the numbers for regression being substantially smaller than the erratic. Clearly, these 3 items have provided Ss with an opportunity to be indecisive in their explanatory behaviour, and the indecision is marked more by erratic features rather than regressive ones. Perhaps the inability of Ss to understand fully the nature of impact overtly expressed in the cases of glass and train, and covertly inferred by clocks stopping, that produces this weighting towards indecision?

Figure No. 15 Showing % No. of Ss registering Modal Patterns for individual items - Malfunctional Stimulus Material Experimental Group (N = 80)

Key: L = Linear P = Progressive R = Regressive
E = Erratic



(ii) Death, Boat Sinking and Balloon Bursting

These items have no common underlying causation such as impact. Death is presented as a malfunctional situation related to living organisms, sinking is the reverse of flotation and the balloon bursting brings in pressure. For all three items, the numbers of Ss that register regression is almost double that for the first three. Is it that the type of malfunctional causal situation - represented by each of these 3 items promotes more regressional patterns? The results for sinking and balloon bursting show a substantial difference between the numbers registering linear and progressive patterns, and this reflects the trends shown for the other malfunctional items. However, in the case of death only a few Ss register more progressive patterns than linear ones.

Therefore, when Ss respond to most malfunctional items, many either consolidate a "no change" pattern of explanation, or realise their potential along progressive lines to a substantial degree. The fact that exploring the causes of death bearly matches this general trend, indicates explaining "death" has special features which give rise to this polarity of "no change" and "positive change".

In examining the results of the controls, the trends seem to indicate for all three items that practice is not a serious factor to consider in explaining these Ss' causal appreciation. The results of the controls for death show more or less equal numbers of Ss registering linear and progressive change, mirroring the same trends (although slightly reversed) for the experimental group and reinforcing the polarity for this item.

10.2.2 Treatment of the Data using a Two Way Anova mixed Design

The results are presented in Table Nos. 19 and 19a in this section and Table Nos. E_{1a} to E_{1f} in Appendix E. The details of this statistical test can be referred to in Versey (1980a), Winer (1971).

Apart from two instances all the F values are highly significant above the .01 level significance. The results of the familiar material which gives a very high F value of 22.04, shows the differences that exist between the three testings. The fact that more Ss give high category explanations is reflected in this high F value for between Ss sources. The results for the controls shows a much lower F value, but above the .01 level of significance for this sample size. This indicates, that the progressive trends which mark the greatest degree of change are not only significant, but significant for both experimental and control settings. This gives some indication that as progression appears to be a feature it is not accompanied by any substantial practice effects, for progression appears to be a feature of control Ss too. However, as the F values are much larger relatively speaking, practice is probably playing some part in the changes of experimental Ss. Familiar causal contexts appears to promote less within S variance, but this masks many examples of individual Ss showing several different patterns of change. As far as the controls are concerned, the within S variance is large for this type of stimulus material.

In examining the results of the remote material, between Ss variance provides the largest F value and this reflects at a global level, the tremendous variety of change shown by various Ss in the experimental group. This trend is also marked for control Ss and is not unlike the results obtained for the familiar stimulus material. The within Ss variance also reflects the variety of change which individuals

TABLE No. 19 Showing F Values* for the 3 types of Stimulus Material

Experimental Group N = 80 (p < .01)

Variation Source	Types of Material		
	Familiar	Remote	Malfunctional
Between Ss	22.04 (df 1,78)	27.14 (df 1.78)	19.37 (df 1.78)
Within Ss	7.37 (df 2,156)	20.82 (df 2,156)	34.09 (df 2.156)
A x B	2.76 (df 2.156)	1.97 (df 2.156)	1.89 (df 2.156)

TABLE No. 19a Showing F Values* for the 3 types of Stimulus Material

Control Group N = 32 (p < .01)

Variation Source	Types of Material		
	Familiar	Remote	Malfunctional
Between Ss	11.80 (df 1,30)	14.79 (df 1,30)	18.77 (df 1,30)
Within Ss	21.53 (df 1,30)	4.6 (df 1,30)	22.65 (df 1,30)
A x B	.18 (df 1,30)	3.3 (df 1,30)	5.65 (df 1,30)

* Statistical Treatment : Two way Anova Mixed Design

show as a result of the treatment. This is however not a marked feature for controls, where the F value is below the .01 level of significance.

The F value for malfunctional material for between S variance is the smallest for the three groups, but is still highly significant. The variance for control Ss almost approaches that for the experimental group, which indicates that malfunctional causal situations provide similar trends in the way Ss change over the test period. The F value for within Ss variance for malfunctional context, is the largest of all values and is again mirrored in the control Ss. From what has been discussed earlier in Chapter 9 and what follows in sections 10.3 and 10.4 in this chapter, a large within Ss variance is not so surprising, judging from the variety and nature of change encountered in malfunctional causal settings.

The F values for between Ss variance is also reflective of sex differences in which boys show more progression than females. However, only references to trends on an item to item analysis can reveal the exact nature of sex differences, and this is taken up in subsequent sections. Nevertheless, the nature of the stimulus material even at a global level indicates that it is factor to be noted. Remote material clearly promotes larger differences between boys and girls than does familiar and malfunctional. Again, the malfunctional context emerges as an interest point here, in that such contexts provide the least opportunity for sex differences.

While the Treatment of the scores for the initial causal component using a Repeated Measures Design, gives valuable information about the extent of the differences which Ss register for each type of stimulus material, it only superficially reflects the enormous and diverse nature of individual changes that have been found in this investigation. It appears therefore from the Repeated Measures treatment, that the greatest change over the three testings has taken place in the remote material with familiar and malfunctional, following in that order. However, as far as the controls are concerned the largest variance is recorded by Ss responding to malfunctional situations, and to a lesser extent remote and familiar respectively. The within Ss variance for experimental Ss shows a progression from low to high F values for familiar, remote and malfunctional stimulus situations, which reflects the variety shown by individuals Ss to remote and especially malfunctional contexts. This variety is also reflected by the control Ss for malfunctional but not remote material. However, within Ss variance for familiar material in the case of controls was larger. The highly significant results which the application of a Repeated Measures statistical treatment has revealed, will now be analysed in more detail, to discuss the nature and variety of change shown by individuals and groups of individuals, which is the essence of any longitudinal study on cognitive development.

10.3 Modal Pattern Analysis (MPA) (Refer to Appendices E_2, E_3 and E_4)

The section is divided up as follows :-

- 10.3.1 Linear Patterns
- 10.3.2 Progressive Patterns
- 10.3.3 Regressive Patterns
- 10.3.4 Erratic Patterns
- 10.3.5 Comparisons with Control Ss

In this section each of the four modal patterns will be examined with special reference to the pattern types. The emphasis will be put on a discussion of the actual patterns rather than on individual items. However in view of the intimate relationship that exists between item and pattern and further, pattern type, reference will be made to individual or groups of items. Most of the results referred to here, will be those from the experimental group, although mention will be made of the results from the control group where necessary.

The reader is referred to Chapter 8 page 180 also Table No. 7a, for details of the construction of modal patterns. However, it is necessary to point out, that the procedure of Modal Pattern Analysis (MPA) was developed by the author as a descriptive measure, to monitor small changes in children's causal explanation over time. In other words it was devised to measure and analyse qualitative longitudinal data owing to the inadequacy of existing statistical techniques, e.g. Markov Chain, scaling, multi-dimensional scaling etc. to interpret the present findings.

10.3.1 Linear Patterns

Linear patterns are sequences of explanatory behaviour in which no appreciable change* takes place over 14 months. In the case of Ss responding to familiar causal situations the frequency for this pattern is about a quarter of all Ss. The pre-dominant pattern type for the items making up the familiar stimulus material is the 3 - 3 - 3 and the 4 - 4 - 4 sequences. Translated into linguistic terms, most items were answered by the Ss in one or two word explanations, or showed the traces of relational thinking directed to the explanation of cause as in a category 3 response. The 4 - 4 - 4 pattern type was by far the most frequent and tended to be given by females more than males, while males gave more 3 - 3 - 3 sequences. Overall, the number of 2 - 2 - 2 patterns tended to be small, but for some items like the bicycle mechanism** a relatively large number of Ss i.e. 11 registered this type of sequence. Pattern type 1 - 1 - 1 was rare occurring only for the bicycle item; 6 - 6 - 6 patterns were registered by a few Ss but there were no 5 - 5 - 5 or pre-causal explanations making up the linear pattern, this latter finding is an expected result.

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* Some changes are registered but are masked by collapsing of categories

** See Table No. 22c.

In examining the results of the remote stimulus material, the linear patterns are dominated by the 5 - 5 - 5 or 6 - 6 - 6 types. In other words, out of approximately a third of Ss that registered linear patterns for this type of stimulus material, most gave pre-causal or don't know responses. However, to items like "space", "dreams" and "rain" no pre-causal sequences were registered. On the other hand, the majority of 6 - 6 - 6 pattern types were given to these items. No 1 - 1 - 1 type was registered but several instances of 2 - 2 - 2 sequences were recorded.

Finally, the results for malfunctional causal situations show that the Ss gave higher explanatory categories, especially more 2 - 2 - 2 for males, and that one or two word explanations were rare as were don't knows. However no 1 - 1 - 1 were registered. These results show therefore, that malfunctional causal situation appear to promote higher quality responses by children, and were maintained over a 14 month period.

10.3.2 Progressive Patterns

The results of progressive patterning will be treated under the three sub-headings; gradients, lags and plateaus.

(a) Progressive gradient

All three forms of progression exhibit an increase in the quality of causal explanation over the 14 month period. The results show, that as far as progressive gradients are concerned, less Ss showed this form of improvement than either for lags or plateau. More Ss registered gradients in the explanations of remote material and rather less for malfunctional. However the least number of Ss registering gradients were for familiar contexts. Although the differences are not that large between the three types of stimulus material for this type of progression, the indication is that with less familiar items, a gradual stepwise development appears to be a feature, while malfunctional contexts also appears to promote this type of change in some Ss. As far as familiar material is concerned, the familiarity surrounding the items obviously promotes less gradual change and instead produces, rapid jumps during the first, second and third testings. Perhaps the most remarkable feature about the analysis of gradients, is that more males exhibit the trend than females. In examining the detailed pattern type most frequently registered by Ss, the 4 - 3 - 2 one was the most commonly shown. This may be a predictable pattern type as it goes from a one-word response; to an embryonic causal explanatory phrase; to an explanation that is relational, fairly correct and showing causal appreciation at a reasonably high level.

(b) Progressive lags

The results show that well over one third of all Ss registered different forms of progression, and by far the greater number of Ss gave a lag or plateau type pattern, more Ss giving plateaus than lag for all 3 types of stimulus material. In examining the frequency of lags for the familiar items, it appears that lag pattern type 4 - 4 - 3, is clearly the one most children register. From this it may be concluded, that familiar items provide causal situations to which many children begin to answer in one or two words phrases, and there is a period of consolidation as indicated by the second test. Then, an upward movement to a more qualitative explanation takes place by a third testing. The other pattern type which appeared fairly frequently in the results was the 3 - 3 - 2 lag, and this was registered by more males than females. So for familiar stimulus material, what progressive lags were registered; by far the largest number were the 4 - 4 - 3 and rather less for 3 - 3 - 2.

It appears from examining the results of the Ss giving lag patterns for remote stimulus material, the pattern type 4 - 4 - 3 is the most common. However, lag type progressions are not a feature for Ss responding to this type of stimulus material. The number of Ss is considerably below that, for those giving such patterns to familiar or malfunctional situations.

The results for malfunctional items show that Ss gave a large number of lags, almost as much as for familiar material. The dominant pattern types included 3 - 3 - 2 and 4 - 4 - 3 mainly, with well over a half the Ss giving the 3 - 3 - 2 sequence. Once again, the trend that emerged in the first part of this investigation in which higher quality explanations were associated with malfunctional situations, seems to be borne out longitudinally. Of further interest, is that many Ss end up with a 2 category explanation; an explanation that contains a high degree of relationality directed towards causal appreciation. However, sex differences must be taken into account when analysing the data and more females register the 4 - 4 - 3 sequence than males, while on the other hand more males give the 3 - 3 - 2 sequences. The occurrence of such constant and often large sex differences, has been further discussed in the section concerned with the Two Way Anova repeated mixed measures treatment, where the F values for between Ss sources of variance indicated a large variance. It is these sex differences therefore that are contributing to the high F values.

(c) Progressive Plateaus

Plateau patterns are sequences in which there is consolidation of a higher explanatory category after the second testing, and is therefore more likely to be the truer picture of the development of a Ss causal thinking. In examining the results for the familiar stimulus material, a relatively large number of Ss gave this type of modal pattern. The most dominant pattern type was a 4 - 3 - 3 i.e. a pattern in which early or embryonic traces of causal explanation are consolidated after seven months and maintained for another 7. Some way behind, is the 3 - 2 - 2 pattern, showing the consolidation of a higher category, namely category 2. A smaller number of Ss gave a 6 - 4 - 4 plateau and all these Ss were female. However for the other pattern types no large sex differences are apparent.

In the case of remote stimulus material, plateau patterns are much less a feature of the performance of this sample than it is for familiar or malfunctional stimulus material. The most frequent pattern type recorded is the 4 - 3 - 3 followed closely by numbers registering the 3 - 2 - 2 sequence. Of less frequent occurrence is the 4 - 2 - 2 and 6 - 3 - 3 pattern types. Sex differences are not a feature for this type of stimulus material where Ss register plateau type patterns.

The results for the malfunctional stimulus material, show that a large number of Ss registered plateaus for these items. The dominant pattern types being 3 - 2 - 2, 4 - 3 - 3 and 4 - 2 - 2 respectively, and in that order numerically. Large sex differences exist in the case of the 3 - 2 - 2 pattern type with more males giving this pattern than females. Although there were sex differences in the case of 4 - 3 - 3 and 4 - 2 - 2 they were not large ones.

Once again the malfunctional context seems to be promoting higher levels of causal explanation, not only initially on first testing, but improving this level during the subsequent 2nd and 3rd testings.

Summarising the trends for the progressive type of changes in children's causal thinking, it appears that of the three possible types of progression, plateau patterns are registered more frequently than for the other two i.e. the lag and gradient. However, plateau patterns are not as distinct a feature in situations that relate to remote levels of experience. The most dominant pattern types whatever stimulus material is being presented are 4 - 3 - 3 and 3 - 2 - 2 with 4 - 2 - 2 coming somewhat behind these. Sex differences are not marked in the case of the pattern types for familiar and remote material, but far more males gave 3 - 2 - 2 sequences than females when Ss are presented with malfunctional causal situations. Another feature about plateaus registered by Ss in malfunctional situations, is that more category 2 explanations are consolidated over the second and third testings than is the case for the other stimulus materials. The occurrence of category 2 explanations was a feature which emerged in the first part of this investigation for most malfunctional situations, and which is maintained as a feature longitudinally in the pattern of causal thinking.

Lag patterns account also, for a substantial amount of progressive change although, like plateaus, lags are not such a distinctive feature when Ss explain remote causal situations. The dominant lag patterns are 4 - 4 - 3 and 3 - 3 - 2 in which large sex differences are a marked characteristic. The male Ss incidentally, tend to register the 3 - 3 - 2 more than the females.

Perhaps one of the most interesting features arising out of an examination of progressive change; is the low incidence of Ss registering gradients. Gradual change is clearly not a feature of causal thinking as it is conceived in this investigation. Change is either a "plateau" or "lag" affair for most Ss. Another interesting trend detected in this study is that far more boys register gradients than did girls.

10.3.3 Regressive Patterns

Regression to a lower developmental status is perhaps the most intriguing and difficult process to explain, especially in the context of the Piagetian Paradigm, with its whole emphasis on hierarchical stages and the successive levels of mental development showing sequential processes

To Piaget, progression is the natural and only developmental direction in which childrens' mental development is conceived. As far as regression is concerned, this is not supposed to happen. However Almy et al (1966) reports in longitudinal studies of conservation of number and quantity, that by the fourth of five interviews there was evidence of regression for several Ss. This is in contrast to Piaget's foreward to Almy's book in which he reports no regression for his longitudinal study.

More recently, Versey (1974) in his longitudinal study of conservational notions of liquid and solid quantity and weight, showed that 20% of Ss return to non-conservation at some point during the testing period. The results for this study, also show that as far as causal thinking is concerned regression takes place and to quite a marked extent. However, what Almy et al and later Versey term regression, is really "vacillation" for their Ss returned to a former status. In this study these patterns were also recorded but are termed erratic modal patterns. The present section deals with "pure regression" in which over the 14 month period no return was made to a higher developmental status. Regression patterns, were recorded especially for remote stimulus material but also for, familiar and malfunctional stimulus material. Sex differences were recorded for familiar and remote materials, with more females registering regressive patterns than males.

The patterns obtained for familiar material, show that Ss concentrated their responses mainly as lag patterns and the most common were 2 - 3 - 3 3 - 4 - 4 and 4 - 6 - 6. Plateaus and gradients were rare. With reference to the 4 - 6 - 6 pattern type, one or two word responses gives way to "don't knows" and are maintained as "don't knows" over 2 of the 3 testings. It might be argued that the "psychological distance" between response category 4 and 6 is not great and that perhaps memory or motivational factors are more likely to be operating here. However, the 3 - 4 category difference and moreso the 2 - 3 difference represent much greater gaps in "psychological distance," for in the former, relational causal thinking has appeared and in the latter case it is well established. In other words, the higher the categories a S registers and then drops, the more difficult it is to account for. Plateau type patterns were registered by only a few Ss, and the most frequently occurring one was 3 - 3 - 4. What one would have envisaged as a fairly established 3 - 3 by the 2nd testing becomes devalued to a 4 on the third testing.

The results for remote stimulus material, show that lag patterns were the most commonly registered form of regression, with plateaux and gradients being rare occurrences. The most frequent pattern types were 5 - 6 - 6, 4 - 6 - 6, 3 - 6 - 6 and 2 - 3 - 3. The first three pattern types, all feature category 6 explanations in their second and third testings. The 5 - 6 group may be the stage at which Ss are developing away from pre-causality but not sufficiently so to register a naturalistic one or two word causal explanation? Perhaps a 4 or 5 test longitudinal design, could reveal a sequence in which a category 4 type explanation might emerge? Clearly, the 4 - 6 and 3 - 6 gaps show that one or two word responses or explanation with some relational causal elements, were not sufficiently established by the S in question, so a "don't know" response became consolidated.

The results for the malfunctional stimulus material, show once again as for remote and familiar material, that Ss resorted to lag type patterns in their regression. The most dominant pattern type was the 2 - 3 - 3, and so even in the context of regression, the malfunctional causal situation involves higher explanatory categories, than for other stimulus materials. No marked sex differences exist in the case of malfunctional material.

Summarising; regression patterns are a feature of all three types of stimulus material, the extent to which any discernible group trends exist however, is related to the different causal contexts probed in the three types of stimulus material. More groups of Ss register regressive patterns when responding to remote material than for either familiar or malfunctional. In analysing the type of regression patterns; differences emerge between the three types of stimulus material. For familiar material, regression is a matter of 2 - 3. 3 - 4 drops, all lags and which sex differences indicate more boys registering the former and more girls the latter gap. The main groups of Ss registering regression for remote material, showed that lags again were a dominant pattern type with drops from 5 - 6 the most commonly occurring, followed by 4 - 6 and 3 - 6 respectively. No marked sex differences were evident. Again the feature of lag pattern and **small** sex difference, were common for Ss registering the 2 - 3 - 3 drop for malfunctional material which is the most constantly recurring pattern type.

10.3.4 Erratic Patterns

Erratic patterns of causal explanation are characterised by the level of the response category on the second testing. The level must always be the highest for apical or humping patterns or the lowest for depression or bumping patterns. Erratic patterns of causal explanations in the context of a longitudinal design, indicate an instability on the part of the Ss, leading to an overall picture of developmental change typified by indecision.

In examining the results for the familiar stimulus material, Ss registered apical as well as depression type patterns, and for both types, symmetrical patterns were more numerous than asymmetrical ones. Of the apical types, 4 - 3 - 4 and 3 - 2 - 3 patterns were the most commonly registered with more Ss giving the former than the latter. In the case of 4 - 3 - 4 pattern, this was registered by seven Ss in their answers to motor car movement. The distribution of the 3 - 2 - 3 was dispersed more evenly amongst several familiar items. The depression or bumping types were mainly 3 - 4 - 3 and 2 - 3 - 2 patterns, with the former type being given by substantially more Ss than the latter type. Only a few registered a 3 - 6 - 3.

The occurrence of particular erratic patterns, common to a group of Ss is less marked for the remote type of stimulus material, than for either familiar or malfunctional items. However, apical and depression effects were registered by Ss, with more of them giving depressions than apical pattern types. The dominant apical pattern was 4 - 3 - 4, while 3 - 4 - 3 was the most registered type for the depression or bumping effect.

In the malfunctional items, again apical and depression patterns were registered by the Ss, and the main trends were symmetrical for both. There were no large differences in the number of Ss giving either pattern and like familiar, and to a lesser extent for remote, no marked sex differences for the erratic patterns emerged. The most widespread pattern types for the apical effect were 4 - 3 - 4 and 3 - 2 - 3 with many more Ss giving the latter type than the former. As for the dominant bumping effect type, the 3 - 4 - 3 and 2 - 3 - 2 sequences were given by most Ss. The former pattern type being given by more Ss than for the latter.

It needs to be emphasized, that in analysing the nature of erratic patterns, there were many diverse types registered and what has been discussed above, only attempts to examine the main trends shown by groups of Ss of not less than 5. When the erratic patterns registered for remote stimulus material are analysed and compared with the other stimulus items, by far the greater number of Ss gave individual forms of erratic patterning. Therefore, it may be concluded that in answering remote causal situations as far as erratic patterns are concerned, there is a distinct tendency for Ss, presumably due to the remoteness of the items, to give a large degree of diversification in erratic patterning. While some Ss gave evidence of this diversification in items included under the familiar and malfunctional materials, it was not a dominant feature of these causal contexts.

Summarising; the most marked feature concerned with erratic patterns is the enormous variety of pattern types registered by Ss to all three types of stimulus material. However, in a section that can only cover the gist of the changes taking place, it is not possible to discuss every individual pattern type. The reader is referred to the analysis of individual items in Appendices E_2 E_3 and E_4 if these details are required.

Both the main sub groups of erratic patterning i.e. apical and depression types are represented by the Ss registering this pattern of change. However, it is clear that two very marked trends appear in the results; (a) most apical or depression effects are symmetrical; (b) no marked sex differences occur. In examining the familiar stimulus material, no marked differences exist in the numbers registering either apical or depression effects, and what dominant pattern types occur, concentrate around 4 - 3 - 4 or 3 - 4 - 3 respectively. Patterns involving 3 - 2 - 3 and 2 - 3 - 2 movements, are also fairly characteristic. Ss giving erratic apical or depression patterns for remote situations are mainly 4 - 3 - 4 and 3 - 4 - 3 respectively, but many more Ss indicated the latter type of depression effect. However, erratic patterning is more a marked feature of Ss' responses to remote stimulus material, than it was in their explanations for the other two types.

Results for the malfunctional material show, that as in the case for familiar material, no marked differences occur in the number of Ss registering either apical or depression effects. However, a fairly marked trend is the concentration around 3 - 2 - 3, 2 - 3 - 2 and 2 - 4 - 2, indicating changes concerned with the higher category 2 explanation. Therefore in erratic changes, the malfunctional context once again is associated with higher levels of explanation.

10.3.5 Comparisons with the Control Ss

The use of controls in this investigations was mainly to monitor the effect of practice and this is discussed at length in the item case studies. However in the experimental design that was developed for this study, the 32 control Ss were actually tested twice, giving the most elementary of longitudinal designs i.e. pre and post test. By inserting one, two or more tests between the pre and post tests, a much more detailed picture of a child's development can be obtained. In this investigation, time allowed only for one test to be inserted between the first and last tests. However, even a three test longitudinal pattern reveals substantial information about the Ss treated in this way, as the discussion in this and other sections have shown. By comparing trends between 2 and 3 test designs one is able, in the case of linear patterns to examine to what extent patterns are linear, over 14 months in this case. Or, whether there has been a change upwards or downwards in the meantime. For progressions or upward change, a 2 test control design indicates the extent of the consolidation process for the first and second testing in the lag pattern, or the consolidation after second testing in the plateau, by the third testing.

Again the 3 test control design gives more information about regressive patterns or downward change related to consolidation processes. The fact that erratic patterns can only be detected using a three or more test design, means that by using a two test control design, useful comparisons can be made with Ss registering erratic patterns. Such comparisons could indicate the extent to which a particular sample exhibits various vacillatory movements and under what conditions etc..

10.4 Case Studies of Selected Items

Five items have been chosen for discussion in this section out of the eighteen that appear in the PCTB. The five items are as follows:

10.4.1 Boats floating and sinking (2 items)

10.4.2 The Bicycle Mechanism

10.4.3 The Rain item (with some reference to lightning; 2 items)

10.4.1 Boats floating and sinking (Refer to Table Nos. 20 and 21)

The floating and sinking of a boat represents a positive and negative type of stimulus material. Both could be considered as familiar situations, but their causal contexts are different. These two contexts were chosen as they represent the same object and it would be interesting to find out (a) the types of explanation that were registered for the two contexts and (b) to examine how they changed or did not, as the case may be over 14 months. Therefore these two items will be discussed together.

A detailed statement of the results are to be found in Table Nos. 20_{a}, $20_{b,c}$ and $21_{a,\ b,\ c}$. However, only the main trends will be discussed below and these will be considered under the four main Patterns.

Linear Patterns

For the boat floating item, some Ss registered 6 - 6 - 6 pattern types not a feature of the malfunctional context. However, all the other pattern types found in the positive familiar context were also found in the malfunctional namely 2 - 2 - 2, 3 - 3 - 3 and 4 - 4 - 4. There are nevertheless large differences in the number of Ss registering each type of pattern. Only a few Ss gave 2 - 2 - 2 sequence for the boat floating item, while most Ss gave it in the malfunctional context. It is clear that 3 - 3 - 3 and 4 - 4 - 4 sequences are more characteristic of floating for these Ss when they answered this item, while 2 - 2 - 2 and 3 - 3 - 3 were a feature for the boat sinking item. This trend has been reported earlier; in which malfunctional contexts promote higher quality explanations which are sustained over time.

Progressive Patterns

Approximately, the same number of Ss gave progressive patterns in either context, however, more gradients were registered for the malfunctional context, while lags were much more a feature of floating, and plateaus more characteristic of sinking. This indicates, that most Ss took less time to consolidate the negative context in explaining causation, while Ss answering the positive context, consolidated the lower explanatory levels, before an emergence to a higher category response is given by the end of 14 months. The 4 - 4 - 3 sequence was the most commonly recorded lag for floating, with the 3 - 3 - 2 coming some way behind. The most common

SUMMARY TABLE

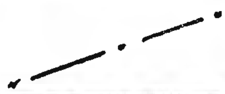
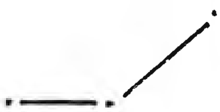
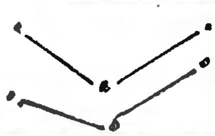
TABLE No. 20a — Showing Modal Patterns for Experimental (E) and Control (C) Groups - Boat Floating Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		24	15	30	47
Progressive		30	14	37	44
Regressive		9	3	11	9
Erratic		17		22	
	Total	80	32	100	100

TABLE No. 20b — Showing Types of Modal Pattern for Control (C) Group - Boat Floating Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		3 - 3	5	2	7	15	47
		4 - 4	1	7	8		
Progressive		3 - 2	2		2	14	44
		4 - 2	1	2	3		
		4 - 3	6	1	7		
		6 - 3		1	1		
		6 - 4	1		1		
Regressive		3 - 4		1	1	3	9
		3 - 6		1	1		
		4 - 6		1	1		
	Totals		16	16		32	

TABLE No. 20c Showing Types of Modal Pattern for Experimental (E) Group - Boats Floating Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	3		3	24	30
		3 - 3 - 3	7	3	10		
		4 - 4 - 4	2	5	7		
		6 - 6 - 6	1	3	4		
Progressive		3 - 2 - 1	1		1	33	41
		6 - 4 - 2		1	1		
		2 - 2 - 1	1		1		
		3 - 3 - 2	2	2	4		
		4 - 4 - 3	3	3	6		
		6 - 6 - 2		2	2		
		6 - 6 - 3		1	1		
		6 - 6 - 4		3	3		
		3 - 2 - 2	2		2		
		4 - 2 - 2	2		2		
		4 - 3 - 3	4	2	6		
		6 - 3 - 3	1		1		
Regressive		2 - 3 - 3	1	2	3	9	11
		4 - 6 - 6	1	3	4		
		2 - 2 - 3	1		1		
		3 - 3 - 4		1	1		
Erratic		3 - 2 - 3	2		2	17	18
		4 - 2 - 4	1	1	2		
		4 - 3 - 4	1	3	4		
		6 - 4 - 6		1	1		
		4 - 3 - 2	1	1	2		
		6 - 3 - 4	1		1		
		4 - 3 - 6		1	1		
		3 - 4 - 3	1	1	2		
		3 - 6 - 3		1	1		
		3 - 4 - 2	1		1		
	Totals		40	40	80		100

sequence for sinking was at a higher level namely; the 3 - 3 - 2, while the 4 - 4 - 3 was rare. So the quality of the explanation on the third testing was generally higher for the sinking of boats. More females gave lags for the floating than males, while no sex differences emerged for sinking.

Plateaus were very much a feature of sinking, with not very marked sex differences. The most commonly registered plateau was 3 - 2 - 2 with 4 - 3 - 3 coming next. In the results for floating, plateaus were largely registered by males and the most common was the 4 - 3 - 3. Yet again, one meets the trend of higher explanatory categories being given by Ss in malfunctional contexts, this time through plateau patterns.

Regression Patterns

These patterns were a feature of both floating and sinking and there are no marked differences in the numbers registering them for either item. More Ss gave lag regressions in answering the floating item, while there was little difference between lags and plateaus for sinking. Females tended to show more regression in their patterns of explanation to floating, while no marked sex differences occur for sinking. Generally speaking it can be concluded, that as far as regression is concerned, lags are more a feature of a positive context such as floating, while no distinct trend emerges for the malfunctional except that lags and plateau occur to about the same extent.

Erratic Patterns

Apical or humping patterns were the most commonly recorded erratic patterns for either floating or sinking, but again, the quality of the

SUMMARY TABLE

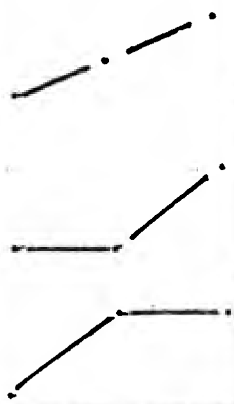
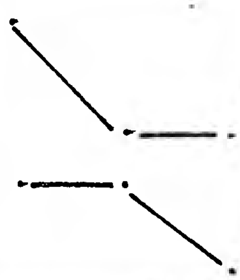
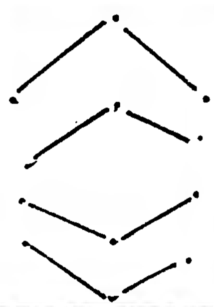
TABLE No. 21a Showing Modal Patterns for Experimental (E) and Control (C) Groups - Boat Sinking Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		20	14	25	44
Progressive		36	14	45	44
Regressive		11	4	14	12
Erratic		13	NA	16	NA
	Total	80	32	100	100

TABLE No. 21b Showing Types of Modal Pattern for Control (C) Group - Boat Sinking Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2	2	3	5	14	44
		3 - 3	2	6	8		
		4 - 4		1	1		
Progressive		2 - 1	1		1	14	44
		3 - 2	3	4	7		
		4 - 3	1	2	3		
		4 - 2	3		3		
Regressive		2 - 3	3		3	4	12
		2 - 4	1		1		
	Total		16	16		32	100

TABLE No. 21c Showing Types of Modal Pattern for Experimental (E) Group - Boat Sinking Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2 - 2	9	3	12	20	25
		3 - 3 - 3	1	6	7		
		4 - 4 - 4	1		1		
Progressive		3 - 2 - 1	1		1	36	45
		4 - 3 - 2		2	2		
		6 - 4 - 3	1		1		
		3 - 3 - 2	4	2	6		
		4 - 4 - 2		1	1		
		4 - 4 - 3		1	1		
		3 - 2 - 2	7	7	14		
		4 - 3 - 3	2	4	6		
		4 - 2 - 2	2	2	4		
Regressive		2 - 3 - 3	2	2	4	11	14
		3 - 6 - 6		1	1		
		4 - 6 - 6		1	1		
		1 - 1 - 2	1		1		
		2 - 2 - 3	2	1	3		
		3 - 3 - 4		1	1		
Erratic		2 - 1 - 2	3		3	13	16
		3 - 2 - 3	2	2	4		
		4 - 2 - 3	1		1		
		2 - 4 - 2		2	2		
		2 - 3 - 2	1	1	2		
		2 - 6 - 3		1	1		
	Total		40	40		80	100

pattern types was higher in the malfunctional context. That is 2 - 1 - 2 and 3 - 2 - 3 were registered for sinking as opposed to 4 - 3 - 4 and 6 - 4 - 6. The variety of pattern types was also much greater for floating than sinking.

Summary

Perhaps the most distinctive difference that emerges in comparing the performance of Ss on these two items, is the higher level of explanatory categories registered for the malfunctional context, irrespective of pattern, for it is a trend that is clearly discernible from linear to erratic sequences. By and large, the results for the control Ss in the case of the boat floating item show similar trends to the experimental group, as far as progressive change is concerned. This trend was also reflected in the progressions recorded for the sinking item. However, a marked difference emerges between the number of Ss registering linear patterns for control and experimental conditions in the malfunctional context. Proportionally more Ss registered linear patterns in the control group than the experimental. A similar picture emerges for the floating item but the difference proportionately is smaller between Experimental and Control groups.

10.4.2 The Bicycle Item (Refer to Table No. 22)

This item was chosen as a case study because it represents the most familiar, judging from Ss' answers to the proforma (see Appendix C_1) and to questions relating to the experiential causal component in the PCTB. The results for this item are found in Table Nos. $22_{a,b,c}$. The number of high categories i.e. 1 and 2 is substantial for this item as predicted, so are the low number for category 6 predictable. However, when one examines these types of responses across the sexes, more males register 1 and 2 type categories, while the few 6 type categories recorded, were given by females. Two major features emerge from the results of the linear patterns; firstly, one word explanations are rare, while the more qualitative 3 and 2 category explanations are fairly evident, especially the latter category. The other feature, is that more males give 2 - 2 - 2 sequences than females, while more 3 - 3 - 3 sequences were given by females. Just under half the Ss in the experimental group gave progression patterns, and all three types of progression are represented. However, more Ss gave plateaus; the dominant pattern types being 3 - 2 - 2 and 4 - 3 - 3 respectively. Also, 2 - 1 - 1 and 4 - 2 - 2 are included but to a much lesser extent. Lag types included 3 - 3 - 2 and 4 - 4 - 3 mainly, and were registered more by females than males, while more males gave the higher category plateaus. By and large, no marked sex differences are indicated for the other plateaus types. Gradients appear to be a male feature but the combined numbers are small.

Regression is clearly a female trend for this item and it is mainly in the form of lag patterns. Erratic changes are characterised, by Ss registering equal number of symmetrical humping and depression effects, and apart from this observation, no other main trend is discernible.

SUMMARY TABLE

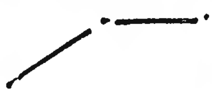
TABLE No. 22a — Showing Modal Patterns for Experimental (E) and Control (C) Groups - Bicycle Mechanism

Pattern	Figure	N		%	
		E	C	E	C
Linear		21	13	26	41
Progressive		36	13	45	41
Regressive		9	6	11	18
Erratic		14	NA	18	NA
	Total	80	32	100	100

TABLE No. 22b — Showing Types of Modal Pattern for Control (C) Group - Bicycle Mechanism

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2	4	2	6	13	41
		3 - 3	3	3	6		
		4 - 4		1	1		
Progressive		3 - 2	3	4	7	13	41
		4 - 3	2	4	6		
Regressive		3 - 2	3	1	4	6	18
		3 - 4	1	1	2		
	Totals		16	16		32	100

TABLE No. 22c Showing Types of Modal Pattern for Experimental (E) Group - Bicycle Mechanism Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		1 - 1 - 1	1		1	21	26
		2 - 2 - 2	7	4	11		
		3 - 3 - 3	2	6	8		
		4 - 4 - 4		1	1		
Progressive		3 - 2 - 1	1		1	36	45
		4 - 2 - 1	1		1		
		4 - 3 - 2	3	2	5		
		2 - 2 - 1	1		1		
		3 - 3 - 2	2	2	4		
		4 - 4 - 3	3	3	6		
		2 - 1 - 1	2		2		
		3 - 2 - 2	3	3	6		
		4 - 2 - 2	2	2	4		
		4 - 3 - 3	4	2	6		
Regressive		2 - 3 - 3		1	1	9	11
		3 - 4 - 4		2	2		
		2 - 2 - 3	2		2		
		3 - 3 - 4		3	3		
		3 - 3 - 6		1	1		
Erratic		3 - 2 - 3	2		2	14	18
		4 - 3 - 4	1	3	4		
		4 - 3 - 6		1	1		
		2 - 3 - 2	2	1	3		
		2 - 4 - 2		1	1		
		3 - 4 - 3	1	2	3		
	Totals		40	40		80	100

Summary

A number of interesting features emerge from the results of this item:

(a) As expected, substantial numbers of Ss registered modal patterns with high category explanations e.g. category 2 and less markedly category 1 explanations.

(b) Again as expected no pre-causal explanations (5) were registered and don't knows (6) were rare.

(c) By and large, many more males registered categories 1 and 2 in their modal patterns than females; so it suggests, that the mechanical nature of a bicycle is still a "male domain", when it comes to explaining its mechanism at higher explanatory levels.

(d) The results of Ss giving linear patterns, show that many Ss especially male, consolidate and maintain their high level of explanation over the 14 months, indicating the ceiling perhaps these Ss have reached in explaining causation. Females appear to do likewise, but at a lower level of explanation.

(e) Just under half the Ss show some form of progression, and while this is expected, the nature of progression has not previously been researched and so these findings are not comparable with other work. The fact that the number of Ss registering gradients is small (but larger than for most other items), means that gradual stepwise progression is not a feature in the development of causal thinking for the bicycle mechanism. However plateau and lag type patterns are features, especially plateaus. It seems therefore, that the appreciation of a bicycle mechanism along progressive patterns, is either a process in which the early consolidation at a higher level is a distinctive character or, is a late rise to a higher explanatory level. No marked sex differences exist for plateau and lag progressions, but more males register gradients than do females.

(f) Regression is given by more females than males, this might be considered an expected outcome in view of the bicycle being considered a male type causal situation to explain. However, this is not a convincing reason, bearing in mind the small number of sex difference that exist for the lag and plateau progressions, which after all constitute the largest portion of improvement in causal appreciation for this item.

(g) Erratic patterns were characterised by only a small number of pattern types. This is in contrast to the results for remote stimulus material, where many diverse patterns of erratic change are registered. This lack of variety in erratic patterning may be symptomatic of <u>very</u> familiar items; meaning that a well known causal situation, as with this item promotes less indecision, when monitored over a certain length of time?

(h) The results for the control Ss indicate that progressive trends were more or less reflected by the experimental group indicating the relatively small role that practice plays in this investigation.

10.4.3 <u>The Rain Item</u> (Refer to Table No. 23)

The rain item was chosen for case study analysis because, at the end of the first year i.e. after the second testing, all Ss in the sample had had direct exposure to the teaching of the rain cycle. It was not possible to set up any detailed control procedure for this item, due to difficulties of timetabling and staffing at the school. The results for this item are to be found in Table Nos. $23_{a,\ b}$ and $_{c}$.

A very marked feature about the results for this item is the enormous variety of explanatory pattern types that the experimental and control groups registered. Rain origin is a remote stimulus item but it was also one that was taught* to all Ss by the end of 14 months of testing. Therefore, two major factors need to be considered when these results are examined, namely, remoteness of the item and effect of teaching the item. The number of Ss registering category 1 type explanations is rare, in fact there are only two instances of such a category and this is registered by two separate Ss on their last longitudinal test. It might have been expected, that more category 1 explanations would have been recorded for an item by the second or third testing, when all the teaching of the rain cycle had been completed. However, this is not the case, but an examination of category 2 frequencies, shows that substantial numbers of Ss either during or by the end of the 14 months, had maintained or increased their category 2 type explanations as part of linear, progressive or erratic patterning. The number of Ss registering category 6 and category 5 response is relatively small, tending in many cases to diminish by the third test. Results for Linear patterns show two trends numerically speaking, a preponderance of 2 - 2 - 2 or maintenance of high quality causal explanation and a 6 - 6 - 6 the maintenance of ignorance! A closer examination of these trends reveal that sex differences are mainly responsible for this polarisation.

The results of the progressive changes show one of the largest number of different pattern types for any item in the PCTB; (see Table No.23c). Also the number of Ss showing progressive change is the largest for the remote items. All three types of progression are represented, with the least number of Ss giving gradients and the most giving plateaus. No dominant pattern type emerges for either the lag or gradient progressions, and sex differences seem to indicate the higher category patterns being registered

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* See Figure No. 19 Appendix A 4 page 413a showing in diagrammatic form the gist and approach of the rain cycle as taught to children in this sample.

SUMMARY TABLE

TABLE No. 23a Showing Modal Patterns for Experimental (E) and Control (C) Groups Rain Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		21	11	26	34
Progressive		31	17	39	53
Regressive		10	4	13	13
Erratic		18	NA	22	NA
	Total	80	32	100	100

TABLE No. 23b Showing Types of Modal Pattern for Control (C) Group Rain Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
		2 2	2	1	3		
Linear		3 - 3	3	2	5	11	34
		6 - 6		3	3		
		3 - 2	1	3	4		
		4 - 2	4		4		
		4 - 3	1	2	3		
Progressive		5 - 4	1		1	17	53
		6 - 2	2		2		
		6 - 3		2	2		
		6 - 5		1	1		
		3 - 4		1	1		
Regressive		4 - 5	1		1	4	13
		4 - 6	1	1	2		
	Total		16	16		32	100

TABLE No. 23c Showing Types of Modal Pattern for Experimental (E) Group - Rain Item

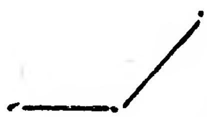
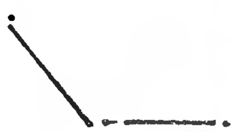
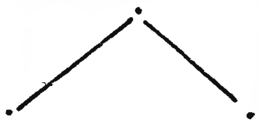
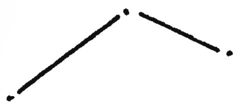
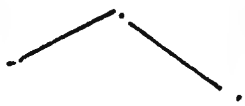
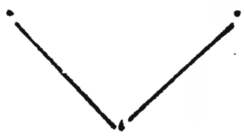
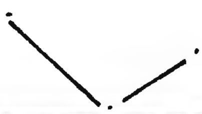
Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	5	3	8	21	26
		3 - 3 - 3	2	1	3		
		4 - 4 - 4		3	3		
		6 - 6 - 6	2	5	7		
Progressive		3 - 2 - 1	1		1	31	39
		4 - 2 - 1	1		1		
		4 - 3 - 2		1	1		
		6 - 3 - 2		1	1		
		6 - 5 - 3	1		1		
		3 - 3 - 2	1	1	2		
		4 - 4 - 3	1	2	3		
		5 - 5 - 3		1	1		
		6 - 6 - 2	1	1	2		
		6 - 6 - 3	1		1		
		6 - 6 - 4	1		1		
		6 - 6 - 5	1		1		
		3 - 2 - 2	4	2	6		
		4 - 2 - 2	3	2	5		
		4 - 3 - 3	1		1		
		5 - 2 - 2	1		1		
		6 - 3 - 3	1		1		
		6 - 4 - 4		1	1		
Regressive		3 - 5 - 6		1	1	10	13
		2 - 3 - 3	1		1		
		4 - 5 - 5	1		1		
		4 - 6 - 6		2	2		
		5 - 6 - 6		1	1		
		2 - 2 - 3		1	1		
		3 - 3 - 4		1	1		
		3 - 3 - 5	1		1		
		4 - 4 - 5	1		1		

TABLE No. 23c (contd.) Rain Item

Pattern	Figure	Pattern Type	N Male	Female	Total		% Total
Erratic		3 - 2 - 3	2		2	18	22
		4 - 3 - 4	1		1		
		6 - 4 - 6		1	1		
		4 - 2 - 3	1	2	3		
		6 - 2 - 3		1	1		
		4 - 2 - 5	1		1		
		5 - 4 - 6		1	1		
		2 - 3 - 2	1		1		
		2 - 4 - 2	1		1		
		3 - 4 - 3		1	1		
		3 - 5 - 3		2	2		
		4 - 5 - 4	1		1		
		4 - 6 - 4		1	1		
		2 - 4 - 3		1	1		
	Total		40	40		80	100

by males. However, two fairly marked pattern types emerge for the plateau i.e. 3 - 2 - 2 and 4 - 2 - 2 with more males giving these than females.

The diverse nature of the pattern types encountered in progressive change, is also a feature of regression however, no dominant pattern emerges at all, together with no marked sex differences.

The results for the erratic patterns also reflect the diversity in the number of pattern types, again with no dominant sequence emerging and no marked sex differences.

In attempting to explain these results it would be useful to compare them with another remote stimulus material item, which did not receive any direct teaching, to see if similar trends are encountered. With reference to possibly the most remote and certainly the most difficult item, namely origin of lightning (see Appendix $E_{3d,e,f}$ and Table No.8 page 210), an explanation may be possible. The lightning item offers the most difficult remote causal situation, however for progressive change, it promotes considerable diversity, so much so that no dominant trend can be extrapolated. Therefore, if remoteness is a factor responsible for "pattern type diversity" then it certainly could be considered as important as the influence of teaching. The lower categories making up these patterns, so much a feature of lightning is most probably an item - specific factor.

However, in comparing the results for the regressive and erratic changes, the number of different patterns are more and of a different quality for the rain item, but not that much more!

Summary

It would seem therefore that the teaching variable is having an effect and that it increases the number of Ss showing pattern type diversity however this seems to be a feature of the most remote item although to a somewhat lesser extent. However, the most striking effect is the level i.e. of explanatory categories constituting the pattern types. For a remote causal situation such as rain origin which has been taught during the the testing period, the number of category 2 and 3 forming a component of a pattern type is much greater especially in sequences that show progressive change. So the effect of teaching a causal situation such as rain origin seems to produce in the first place more diversity in pattern types but secondly and more important for cognition a substantially more qualitative composition to the progressive sequences.

10.5 Case Studies of Individual Children

Eleven individual case studies of subjects will be discussed in this section. The first four studies, will be examined from the standpoint of the preponderance of low or high levels of causal explanation, registered over the 14 month period. The remaining seven case studies, will be discussed on the basis that each of them have fairly distinctive records in their modal patterns e.g. preponderances of linear or progressive plateaus etc. Apart from one case study, namely that showing a gradient progression, all the others are paired on a male/female basis.

The selection of the case studies was based on an arbitrary number of low or high category explanations and modal patterns. In the case of a low category choice, Ss that registered between a third to a half of 4 and 6 response categories, were considered for the analysis. For high category explanations, Ss that registered about a third of all response categories at 1 and 2 levels of explanation were considered. In deciding for the modal pattern* case studies, Ss had to register a frequency

* An exception was made for the case of regression patterns, as the frequency of Ss showing these types was small.

of not less than one third of the same pattern i.e. at least six occurrences of a particular sequence out of a total or 18.

The age given with each Modal Profile is the age recorded on the first testing.

This section is divided as follows:

10.5.1 Individual Ss registering a preponderance of low category explanations

10.5.2 Individual Ss registering a preponderance of high category explanations

10.5.3 Individual Ss registering a preponderance of linear Patterns

10.5.4 A S " " " " Gradient "

10.5.5 Individual Ss " " " " Plateau "

10.5.6 " " " " " " Regressive and Erratic Patterns

10.5.1 Individual Ss registering a preponderance of low category* causal explanations

Individual S Profile

Case Study No. 1 Subject No. 2 Sex Male Age 112 months

Profile of Modal Patterns

Familiar Material		Remote		Malfunctional	
Item	Pattern Type	Item	Pattern Type	Item	Pattern Type
1	$\boxed{4}$ - $\boxed{4}$ - $\boxed{4}$	7	3 - 3 - $\boxed{4}$	13	$\boxed{4}$ - $\boxed{4}$ - 3
2	$\boxed{4}$ - $\boxed{4}$ - $\boxed{4}$	8	5 - 5 - 5	14	$\boxed{4}$ - $\boxed{4}$ - 3
3	$\boxed{4}$ - $\boxed{6}$ - 2	9	3 - $\boxed{4}$ - 3	15	3 - 3 - 3
4	3 - $\boxed{6}$ - $\boxed{6}$	10	3 - $\boxed{4}$ - 3	16	$\boxed{4}$ - $\boxed{4}$ - $\boxed{4}$
5	$\boxed{4}$ - 3 - 3	11	3 - 3 - 2	17	$\boxed{4}$ - 3 - 3
6	2 - 3 - 3	12	$\boxed{6}$ - $\boxed{6}$ - 5	18	$\boxed{4}$ - 3 - 3

The total number of low categories i.e. 4 and 6 for all items together is 25, however many more 4 category explanations made up the total than type 6 (or don't knows). Contrary to the main trends discussed elsewhere, this S registers less lower categories for remote material than for either the familiar or malfunctional material. However by the third test

* These are indicated by "boxing in" each category.

occasion for familiar and malfunctional material, less lower categories were registered. This S performed poorly on the other parts of the PCTB giving no evidence at all of logico-causal reasoning. Performance on the Richmond attainment tests, causal reasoning and causal problem solving were also poor. However, this S was able to conserve substance and weight. Nevertheless, the generally poor performance on the PCTB is reflected in his performance generally in other measures.

The profile for the remote items indicates that for some reason, levels of causal explanation reach the beginning of relational causal thinking.

Individual S Profile

Case Study No.2 — Subject No. 74 — Sex Female — Age 113 months

Profile of Modal Patterns

Familiar Material		Remote		Malfunctional	
Item No.	Pattern Type	Item No.	Pattern Type	Item No.	Pattern Type
1	$\boxed{4}-\boxed{4}-3$	7	$\boxed{4}-\boxed{4}-3$	13	$\boxed{6}-3-3$
2	$\boxed{6}-\boxed{6}-\boxed{4}$	8	$\boxed{6}-\boxed{6}-\boxed{6}$	14	$3-\boxed{4}-3$
3	$\boxed{4}-\boxed{4}-\boxed{4}$	9	$\boxed{4}-\boxed{6}-\boxed{4}$	15	$3-\boxed{6}-3$
4	$\boxed{4}-\boxed{4}-\boxed{4}$	10	$\boxed{4}-\boxed{4}-\boxed{4}$	16	$\boxed{4}-\boxed{4}-3$
5	$\boxed{4}-\boxed{4}-\boxed{4}$	11	$5-\boxed{6}-\boxed{6}$	17	$2-3-3$
6	$\boxed{4}-\boxed{4}-3$	11	$\boxed{4}-\boxed{6}-\boxed{6}$	18	$3-3-3$

The total number of low categories is 37 for all items, however for this S a large number of lower categories are registered for familiar and remote items and much less for malfunctional. These trends are not typical of the main ones, in which familiar is nearer to malfunctional in most cases, whereas here, remote and familiar have the same number of low categories. More "don't knows" were registered for this S than for Case Study 1, and this is in line with the findings for sex differences. Again in accordance with the trends on malfunctional material, higher categories of explanation were given here. By the third testing, less numbers of low category response are registered for familiar and none for malfunctional, but the numbers remain the same for remote. This S, also performed poorly on all the tests administered during the first year, and she did not conserve any of the Piagetian tests. The relatively reasonable performance on some of the malfunctional items indicates however, the strong influence malfunctional causal contexts have, for the improvement of her causal thinking.

10.5.2 Individual Ss registering a preponderance of high Category* causal explanations

Individual S Profile

Case Study No.3 Subject No. 3 Sex Male Age 117 months

Profile of Modal Patterns

Familiar		Remote		Malfunctional	
Item No.	Pattern Type	Item No.	Pattern Type	Item No.	Pattern Type
1	3 - $\boxed{2}$ - $\boxed{1}$	7	4 - 4 - 4	13	3 - $\boxed{2}$ - $\boxed{2}$
2	3 - $\boxed{2}$ - $\boxed{1}$	8	4 - 3 - 3	14	4 - 4 - 3
3	3 - $\boxed{2}$ - 3	9	6 - $\boxed{2}$ - $\boxed{2}$	15	$\boxed{2}$ - $\boxed{2}$ - $\boxed{2}$
4	3 - 3 - $\boxed{2}$	10	4 - 3 - 4	16	3 - 3 - 3
5	$\boxed{2}$ - $\boxed{1}$ - $\boxed{1}$	11	3 - $\boxed{2}$ - 5	17	$\boxed{2}$ - $\boxed{2}$ - $\boxed{2}$
6	4 - $\boxed{2}$ - 3	12	$\boxed{2}$ - $\boxed{2}$ - $\boxed{2}$	18	3 - $\boxed{2}$ - 3

* These are indicated by "boxing in" each category

The total number of high categories i.e. category 1 and 2 is 25 with many more category 2s. The distribution of these categories is in line with trends discussed elsewhere, in that familiar and malfunctional material promote larger numbers of higher categories than does remote material. All the category 1 explanations were registered for familiar material. This S also performed well on most aspects of the PCTB; Causal Reasoning and Causal Problem Solving tests. However, only substance was conserved and the performance on Richmond tests was mediocre. It seems that this S performed very well on most causal measures but this was not reflected in the measures obtained for non causal tests. In this respect S 3 is typical for the trends discussed in Chapter 9 indicating that causal and non-causal abilities are probably different, and therefore are appreciated differently by children.

Individual S Profile

Case Study No. 4 Subject No. 98 Sex Female Age 122 months

Profile of Modal Patterns

Familiar		Remote		Malfunctional	
Item No.	Pattern Type	Item No.	Pattern Type	Item No.	Pattern Type
1	3 - $\boxed{2}$ - $\boxed{2}$	7	4 - 3 - 4	13	$\boxed{2}$ - $\boxed{2}$ - 3
2	3 - 3 - $\boxed{2}$	8	6 - 6 - 3	14	3 - 3 - 3
3	4 - 3 - 3	9	3 - 3 - 6	15	3 - 3 - $\boxed{2}$
4	$\boxed{2}$ - $\boxed{2}$ - $\boxed{2}$	10	3 - 3 - 3	16	3 - $\boxed{2}$ - $\boxed{2}$
5	$\boxed{2}$ - $\boxed{2}$ - $\boxed{2}$	11	3 - $\boxed{2}$ - $\boxed{1}$	17	3 - 3 - 3
6	3 - $\boxed{2}$ - 3	12	$\boxed{2}$ - $\boxed{2}$ - $\boxed{2}$	18	4 - $\boxed{2}$ - $\boxed{2}$

The total number of high categories is 22, with only a single category 1 explanation. More high categories were registered for the familiar items, somewhat less for the malfunctional and in line with the main trends, the least for remote material. The S shows no particular pattern type which includes most of the high categories, for they are fairly widely distributed throughout. Performance on other parts of the PCTB is good and so reflects generally the high level of causal thinking throughout. Unfortunately, it is not possible to compare this S's performance on other tests, as she was not included in the design for the early investigation. However, as far as her performance vis-a-vis the causal measures are concerned, an overall feature is the high levels of explanation that are attained by the second testing, and consolidated by the end of 14 months at the same level. In this respect the performance of this S has plateau characteristics which represents yet another general trend in progressive change.

10.5.3 Individual Ss Registering a preponderance of Linear Patterns*

Individual S Profile

Case Study No. 5 Subject No. 38 Sex Male Age 112 months

Profile of Modal Patterns

Familiar		Remote		Malfunctional	
Item No.	Pattern Type	Item No.	Pattern Type	Item No.	Pattern Type
1	$\boxed{4 - 4 - 4}$	7	4 - 3 - 3	13	$\boxed{3 - 3 - 3}$
2	2 - 3 - 3	8	$\boxed{5 - 5 - 5}$	14	4 - 3 - 3
3	$\boxed{3 - 3 - 3}$	9	3 - 4 - 3	15	$\boxed{3 - 3 - 3}$
4	4 - 3 - 3	10	6 - 4 - 4	16	3 - 3 - 2
5	$\boxed{3 - 3 - 3}$	11	5 - 5 - 5	17	3 - 3 - 2
6	6 - 3 - 3	12	4 - 3 - 4	18	$\boxed{3 - 3 - 3}$

* Indicated by "boxing in" each category

Eight instances of linear patterns were registered by this S, almost a half of the possible total. The distribution of the patterns is fairly equal amongst the 3 stimulus materials; which perhaps indicates that this S's causal thinking as monitored in the study, represents a strong element of consolidation or maintenance of the status quo. Plateaus are also a feature, which is another indication of consolidatory explanatory behaviour. An examination of the linear patterns shows that more 3 - 3 - 3 sequences are registered than any of the others. However, the overall level of the explanatory categories is low, and this is reflected in the poor performance of this S, on the other causal components and non-causal measures i.e. Richmond Achievement, Causal Reasoning etc.

The nature of the stimulus material probably accounts for this linear trend as patterns registered for remote material are pre-causal, reflecting a feature of the study generally. Similarly, all the linear patterns recorded for malfunctional material is made up of category 3 explanations, again reflecting a general feature in that a malfunctional context promotes a higher level of explanation when compared to familiar and remote situations. The S's performance on Piagetian conservation tests, show that substance and area were conserved, while weight and volume were not. The result for conservation of Substance may be in line with the general level of low quality linear patterns of explanation, but conserving area is more difficult to explain. One perhaps can conclude, that causal thinking which is typified by a tendency towards linear consolidation at lower levels of explanation, may be related to poor performance in other tests. As far as concrete operational thinking is concerned, the link is unclear, except that conservation of substance seems to accompany low level linearity.

Individual S Profile

Case Study No. 6 Subject No. 61 Sex Female Age 120 months

Profile of Modal Patterns

Familiar		Remote		Malfunctional	
Item No.	Pattern Type	Item No.	Pattern Type	Item No.	Pattern Type
1	$\boxed{4 - 4 - 4}$	7	$\boxed{5 - 5 - 5}$	13	3 - 4 - 3
2	$\boxed{4 - 4 - 4}$	8	5 - 4 - 5	14	4 - 4 - 3
3	4 - 3 - 3	9	3 - 6 - 4	15	$\boxed{3 - 3 - 3}$
4	$\boxed{4 - 4 - 4}$	10	4 - 3 - 3	16	$\boxed{3 - 3 - 3}$
5	3 - 4 - 4	11	$\boxed{5 - 5 - 5}$	17	3 - 3 - 4
6	$\boxed{4 - 4 - 4}$	12	5 - 6 - 6	18	$\boxed{2 - 2 - 2}$

This S registered a half of the possible number of modal patterns as linear. The distribution of the patterns are represented in all 3 types of stimulus material,but with more for the familiar. The S shows an interesting trend when the components of the patterns are analysed. Clearly,category 4 type explanations are a feature of the linearity in familiar causal contexts, For remote material, pre-causal explanations make up the 2 recorded instances of linearity. Explanatory categories, 2 and 3 compose the linear patterns for malfunctional material. The influence of the type of stimulus material, is once again borne out.

In this specific case study,lower category explanations are a feature of linearity in familiar and remote contexts,while malfunctional ones promote higher explanatory categories. In examining the above profile with respect to other measures, it appears that a profile dominated by linearity is accompanied by poor performance on most other tests, causal and non-causal. So that one may conclude, that where linearity is a constant and prominent feature of causal thinking, and that the explanatory categories making up the linearity are at lower levels; this is matched with poor performance on other tests of ability. Again, the feature which arose concerning substance conservation, discussed in the latter case study appears here, so that low level linearity may be accompanied by the appreciation of substance conservation.

10.5.4 A S Registering a Preponderance of Progressive Gradient Patterns*

Individual S Profile

Case Study No. 7 Subject No. 31 Sex Male Age 116 months

Profile of Modal Patterns

Familiar		Remote		Malfunctional	
Item No.	Pattern Type	Item No.	Pattern Type	Item No.	Pattern Type
1	4 - 4 - 2	7	4 - 4 - 2	13	$\boxed{6 - 3 - 1}$
2	3 - 4 - 2	8	$\boxed{6 - 4 - 2}$	14	$\boxed{4 - 3 - 2}$
3	3 - 3 - 1	9	$\boxed{4 - 3 - 2}$	15	4 - 2 - 2
4	$\boxed{4 - 3 - 2}$	10	6 - 6 - 6	16	4 - 3 - 4
5	$\boxed{4 - 2 - 1}$	11	3 - 2 - 2	17	2 - 2 - 2
6	4 - 3 - 3	12	$\boxed{4 - 2 - 1}$	18	$\boxed{4 - 3 - 2}$

Eight progressive gradients were registered by this S and they were equally distributed between the 3 types of stimulus material. This could

* Indicated by "boxing in"

indicate that much of this S's causal thinking is characterised by gradual progression. The nature of each gradient provides an interesting case of progressive sequence. Characteristically, the S begins with a category 4 (or one/two word explanation), followed by embryonic relational thinking, ending up after 14 months with a competent causal explanation where category 2 explanations are registered. This gradual progression, is a feature of this S's performance on other components of the PCTB, and also on the Richmond test. A further point of interest, is that this S conserved on 3 of the 4 Piagetian tasks giving only a transition category for area. So gradient behaviour for this S seems to be accompanied by fairly typical Piagetian developmental trends. The reasons for gradient behaviour lie in several influences, but an interesting experiential trend shown by this Ss was that much of his informational source for enabling him to answer his questions was through consulting Books. It may be therefore that reading for this S not only initiated causal explanation but increased its quality over the 14 months?

10.5.5 Individual Ss Registering a Preponderance of Plateau* Type Patterns

Individual S Profile					
Case Study No. 8		Subject No. 32		Sex Male	Age 116 months
Profile of Modal Patterns					
Familiar		Remote		Malfunctional	
Item No.	Pattern Type	Item No.	Pattern Type	Item No.	Pattern Type
1	$\boxed{4 - 2 - 2}$	7	5 - 3 - 2	13	$\boxed{3 - 2 - 2}$
2	$\boxed{4 - 2 - 2}$	8	6 - 2 - 4	14	$\boxed{3 - 2 - 2}$
3	3 - 3 - 3	9	6 - 2 - 4	15	$\boxed{3 - 2 - 2}$
4	3 - 2 - 3	10	2 - 2 - 2	16	2 - 2 - 2
5	$\boxed{3 - 2 - 2}$	11	$\boxed{3 - 2 - 2}$	17	$\boxed{3 - 2 - 2}$
6	4 - 3 - 6	12	3 - 2 - 3	18	$\boxed{3 - 2 - 2}$

* Plateau indicated by "boxing in"

Exactly half of the pattern types registered by this S, were plateaus and although the plateau figured in all 3 stimulus materials, the concentration of this pattern was mainly for the malfunctional and familiar materials. A plateau indicates an early ascendency to a higher explanatory category, and its consolidation by the end of 14 months. From the profile above, this type of causal thinking is a characteristic of this S, particularly in malfunctional and familiar causal contexts. Even more of a feature here, is the frequency of a particular pattern type namely the 3 - 2 - 2. This is a type, in which embryonic causal relationships are initially registered and then an increase to a fairly competent causal explanation takes place. This competent explanation is then maintained. It is clear that this S's causal thinking is characterised by consolidatory patterns, and this is perhaps reflected in his performance on the Richmond Achievement Test, where a higher score is attained in the second year, coinciding with the 3rd testing. The plateau pattern is reflected in this S's performance on other parts of the PCTB and other causal measures. The relatively high qualitative performance on the Initial Component of the PCTB, is reflected therefore by the good performance this S shows on the majority of tests, including creativity and his ability to conserve all the Piagetian conservational tasks presented in this study.

Therefore, for this S we have a case of good, and sometimes very good levels of performance on other measures coinciding in part with a plateau type of progression, which is itself consolidating a high level of causal thinking by the end of 14 months. A factor that might partly explain the results for this S, may be found in examining the experiential source as probed in the PCTB. Increasing emphasis during the 14 month period is put on Schooling and Book sources for supplying information, feeding presumably into the S's improved level of causal thinking.

Individual S Profile

Case Study No. 9   Subject No. 75   Sex Girl   Age 114 months

Profile of Modal Patterns

Familiar		Remote		Malfunctional	
Item No.	Pattern Type	Item No.	Pattern Type	Item No.	Pattern Type
1	4 - 3 - 3	7	5 - 2 - 3	13	3 - 2 - 2
2	6 - 6 - 2	8	5 - 5 - 3	14	4 - 2 - 2
3	3 - 2 - 2	9	6 - 3 - 6	15	3 - 2 - 2
4	4 - 3 - 3	10	6 - 3 - 3	16	3 - 3 - 4
5	4 - 2 - 2	11	2 - 2 - 3	17	3 - 3 - 2
6	4 - 3 - 3	12	6 - 3 - 2	18	3 - 3 - 3

Like Case Study 8, half the number of pattern types registered were plateaus but the distribution and in several instances the composition of each pattern type differs from the male case study. More plateaus are found for the familiar material (almost all except one), rather less for malfunctional, and just one for remote. The general qualitative level of the patterns is somewhat lower than for Case Study 8, indicating a greater tendency to consolidate at embryonic levels of causal explanation typified by category 3.

While malfunctional material does not promote as many plateaus, the occurrence of a high category patterning 3 - 2 - 2 is a feature, as it was for the male case study. In comparing these modal patterns with this

S's performance an other measures, the plateau type progression is reflected to some extent in other parts of the PCTB. Performance on the Richmond test also indicates a reflection of the type of improvement shown by a plateau like pattern. Generally speaking, although the level of performance on causal and non causal tests was below that shown by case study 8, the same trends are indicated. That is, performance on causal reasoning, causal problem solving was quite good. As far as performance on conservational tasks is concerned, only volume was not conserved by this S. This is perhaps understandable, with the lower quality of explanations shown in the modal patterns.

An interesting point of comparison with the male counterpart for this type of pattern, is that once again the role of schooling as an experiential variable appears to accompanying the plateau nature of this S's causal thinking. If this trend is a general feature, and time has not allowed further study of this here, the implications for interaction in class and its effects on childrens thinking be it causal or otherwise would be interesting and essential to follow up!

10.5.6 Individual Ss registering Progressive Lags*, Regression* and Erratic Patterning*

Individual S Profile

Case Study No. 10 Subject No. 5 Sex Male Age 113 months

Profile of Modal Patterns

Familiar			Remote			Malfunctional		
Item No.		Pattern Type	Item No.		Pattern Type	Item No.		Pattern Type
1	R	$\boxed{3 - 4 - 4}$	7	E	$\boxed{3 - 4 - 3}$	13	E	$\boxed{5 - 3 - 2}$
2	E	$\boxed{3 - 4 - 3}$	8		4 - 4 - 4	14		4 - 3 - 3
3		4 - 4 - 3	9	R	$\boxed{2 - 3 - 3}$	15		4 - 2 - 2
4	E	$\boxed{3 - 2 - 4}$	10	R	$\boxed{3 - 3 - 4}$	16		4 - 2 - 2
5	E	$\boxed{3 - 2 - 3}$	11		5 - 5 - 5	17		4 - 2 - 2
6	E	$\boxed{4 - 2 - 3}$	12	R	$\boxed{3 - 3 - 4}$	18	E	$\boxed{4 - 2 - 4}$

* Indicated by "boxing in"

R = regressive
E = erratic
L = lag

Regression and erratic patterns will be considered together for this case study, as it seems the frequency with which each of the two pattern types occur, is less than for the other types, especially in the case for regression. A frequency of 4 regression patterns, out of 18 items for any one S is a fairly reasonably substantial frequency for this sample.

The number of erratic patterns is 7 and regression 4. In examining the erratic patterns, all three types of stimulus material contain such patterns, but they are more a feature of familiar than they are of the other two types. Remote stimulus material promotes more regression, and this is a trend met elsewhere in the investigation. The details of the regression pattern indicate, that the drop is mainly from 3 to 4 type explanation categories; although there is one instance of a drop from category 2 to 3. Two of the regressions are plateaus while the other two are lags. Erratic patterns were promoted by more familiar contexts than by the others, and "humping effects" are a feature of these patterns.

Erratic and Regression patterns indicate a certain instability in the pattern of causal thinking, with high points in explanatory categories followed by low ones, or vice versa in the case of some erratic patterning with differences between first and third testing. This instability is a feature of this S's performance on other components of the PCTB, and also the erratic nature of highish scores on some tests like language, and low on causal problem solving relational and sceptical tests.

It appears therefore that this S's tendency to show erratic appreciation of causal phenomena and a lesser tendency to regress, is accompanied by similar indecisive performance on other tests and tasks.

Individual S Profile

Case Study No. 11 Subject No. 72 Sex Female Age 113 months

Profile of Modal Patterns

Familiar			Remote			Malfunctional		
Item No.		Pattern Type	Item No.		Pattern Type	Item No.		Pattern Type
1		4 - 4 - 4	7	R	$\boxed{5 - 6 - 6}$	13		3 - 3 - 3
2	R	$\boxed{4 - 6 - 6}$	8	R	$\boxed{4 - 4 - 6}$	14		3 - 3 - 3
3		4 - 3 - 3	9		4 - 4 - 4	15		5 - 3 - 3
4	L	$\boxed{4 - 4 - 3}$	10		4 - 3 - 4	16		4 - 4 - 4
5	L	$\boxed{4 - 4 - 3}$	11		3 - 6 - 2	17	R	$\boxed{2 - 3 - 3}$
6	L	$\boxed{4 - 4 - 3}$	12		4 - 6 - 4	18	L	$\boxed{3 - 3 - 2}$

The above profile is also a mixed one, including regression and lag patterns. Regression is a feature represented in all three types of stimulus material, and there is a variety in the different drops, although these drops follow certain trends already encountered previously in this investigation. The familiar material has a drop involving 4 - 6 explanatory categories, both fairly common ones for females. One of the remote items, has a 5 - 6 drop generally reflecting pre-causal explanations which are given for this type of stimulus material. The regression patterns given to malfunctional stimulus item represents a drop involving higher categories, i.e. 2 - 3. The regression behaviour of this S, show trends which reflect generally, stimulus item and sex differences encountered previously in this study. In examining lags, the 4 - 4 - 3 is very typical of general trends for females when they respond to familiar causal situations as shown elsewhere in this investigation. Similarly, the higher lag of 3 - 3 - 2 is typical of Ss responding to malfunctional causal contexts.

Comparing this S's performance on other measures, her appreciation of logico-causality showed a distinct regression effect. Her generally low level of causal explanation, is accompanied to a certain extent by a poor performance on most non-causal tests. However, a somewhat baffling result for this S, is that she conserved all the Piagetian conservation tasks except Volume!

PART THREE: ASSESSMENT OF RESULTS, IMPLICATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

CHAPTER 11

ASSESSMENT OF RESULTS AND SUMMARY OF THE MAIN FINDINGS AND CONCLUSIONS

CHAPTER 11

ASSESSMENT OF RESULTS AND SUMMARY OF THE MAIN FINDINGS AND CONCLUSIONS

INTRODUCTION

This chapter will be divided into three sections; these are as follows:

11.1 Assessment of the findings relating to the nature of children's causal thinking and its relationship to other abilities.

11.2 Assessment of the findings relating to the longitudinal study of causal thinking by middle school children.

11.3 Summary of the main findings and conclusions.

11.1 Assessment of the findings relating to the nature of children's causal thinking and its relationship to other abilities

The conclusions reported in this section will be presented under five sub-sections four of which reflect the research problems investigated in the context of guiding Statement 1. The last sub-section is a brief overview of the assessments concerned with Guiding Statement 1. These sub-sections are as follows:

11.1.1 Assessment of the findings rélating to the nature of Causal thinking in middle school children.

11.1.2 Assessment of the findings relating to selected factors affecting children's causal thinking.

NB: As this chapter is concerned with an assessment of the main trends; case study material with its emphasis on specific item analysis and patterns of individuals' development is not included. The reader is referred to Chapter 10 sections 10.4. and 10.5 respectively.

11.1.1 Assessment of the findings relating to the nature of Causal Thinking in Middle School Children

From the outset the author's view of causal thinking has been open-ended, flexible and multiplex. Causality is seen very much in terms of the generative scientific tradition, discussed in Chapter 2. This view has pervaded most of the selection and construction of the instrumentation for investigating causal thinking in this study. It was not the object of this investigation to put forward any new and substantive scientific theory vis-a-vis the causal principle. However it was the intention of the author to set up causal situations that would reflect the current scientific mood on causation. It was also intended to probe how children employed various thinking strategies, to explain causal situations. The formulation of the first research problem aimed therefore, to give a firm direction to the investigation of causal thinking strategies in middle school children. The hypotheses related to the nature of causal thinking, took into consideration, explanatory processes, considered the nature of stimulus material, examined the different modes in which causal situations could be presented and explained. Finally, how other conceptions of causality might relate to the author's view of children's causal thinking was also expressed in the form of an hypothesis.

(a) Explanations of initial causal components

It is clear from the results presented in 9.1.1, that these Ss were capable of explaining various causal situations in a variety of ways. Some Ss showed a diversity in their different forms of explanation, ranging from simple (category 4) to complex (category 1) while others, and these comprised the majority of Ss in the case for many items, tended to exhibit embryonic causal-relational answers (category 3).

It can be concluded therefore, that when children were able to appreciate causal phenomena, they often exhibited ways of expressing this appreciation by employing one of several response categories. For some items and for some Ss, the response was a single word, for others a full and competent explanation. The results therefore support hypothesis (1) i.e. when children explain an initial causal component, their explanation is part of a hierarchical system.

(b) Causal explanation and Age Norms

An examination of Figure No.6 Chapter 9 shows that response categories 2 - 5 were registered by the sample of 102 Ss whose mean age was 115.186 months and having a S.D. of 3.452 (see Table No.4 Chapter 7). Most S's who gave causal explanations could be included in the Naturalistic category used by Nass (1956) and later Berzonsky (1969). They could also be included in Piaget's mechanical explanation, therefore supporting Piaget's age norm for this type of explanation. However, elements of pre-causal thinking remain in the explanation given by some Ss, and mainly when remote stimulus material is used. On the other hand, few category 1 explanations occur. It is however, not possible to compare these more specific results with other research, as former studies have used younger children, and no study has used a categorical system of causal explanation specifically resembling the one used here, although the system of Mogar (1960) comes closest to it.

Therefore it can be concluded, that the hierarchical system used in this study to measure causal thinking was reflected for the most part by children aged 115 months. Furthermore, that the majority of causal explanations are of a mechanical nature and broadly supports Piaget's findings. Therefore, Hypothesis (2) is supported i.e. such a hierarchical system of explanation is a feature of the mean age of the children investigated in this study, but caution must be exercised in making any broad generalisations in view of the lack of any comparable data.

(c) Causal Explanation and the nature of the stimulus material-initial causal components

Examination of the general trends for the three types of stimulus material (see Figure Nos. 6a - c) show, that there are different distributions to the various response categories. Familiar material clearly elicits more category 4 explanations, while malfunctional stimulus material promotes categories 3 and 2 respectively. Remote material on the other hand stimulates more pre-causal explanations (or category 5) and "don't knows" (category 6). From these general trends it can be concluded, that causal explanation as measured by the hierarchical system devised in this investigation, is related to the nature of the stimulus material. Malfunctional causal situations promote higher quality of responses, mostly category 3 and less frequently category 2 type explanations. Familiar material elicits mostly, one or two word causal explanations while remote material promotes pre-causal and mostly "don't know" responses. Therefore

Hypothesis (3) is supported; i.e. a hierarchical system of causal explanation is differentially related to the nature of stimulus material. The results reported above and discussed in more detail in Chapter 9, reflect the findings of earlier workers such as Berzonsky and Nass. That so few category 2 explanations and hardly any category 1 explanations are a feature of this sample, may be due to the fact that this could be reflecting the general level of ability as measured by the Richmond tests and other measures of causal ability. The generally poor performance on conservational notions may also lend support to this contention. Results of the Richmond tests show large standard deviations mirroring a skewed distribution towards the lower end.

In scrutinising the individual items (see Table Nos. 9e, 10b, e, 11e) included in the three types of stimulus material, some comments need to be made. The bicycle item as expected, elicited the largest number of higher category responses i.e. 1 and 2, presumably due to its extreme familiarity. The dominant feature of pre-causal (mostly phenomenistic) explanation of remote causal situations was especially a feature of lightning and the origin of night. These items also promoted large numbers of 'Don't knows". The results for these two remote items, clearly showed the difficulty which these children of first year middle school encountered. Finally, the boat sinking item typified the general trend of a preponderance of category 3 and 4 explanations for malfunctional material. However, of further interest in this item is the large number of category 2 explanations. Analysis therefore of certain individual items from the three types of stimulus material, clarified further the differential nature of causal explanation for situations reflecting different levels of experience.

(d) Causal thinking and the nature of the stimulus material - other causal components

Examination of the general trends for the other causal components show, that appreciation of causal plurality, causal probability and logico-causal components are related to the nature of the stimulus material. Malfunctional causal situations clearly promote a greater appreciation of all the above three components than do familiar or remote ones. Therefore Hypotheses (4), (5) and (6) are supporded in that appreciation of pluralistic, probabilistic and logico-causal components are differentially related to the nature of the stimulus material. Furthermore, malfunctional, familiar and remote stimulus material promote respectively, more qualitative causal thinking as measured by the PCTB.

It is clear from these findings discussed above, that malfunctional causal situations stimulate not only higher levels of causal explanation, but promote a higher degree of causal analysis as expressed through appreciation of plurality, probability and logico-causal reasoning. Remote situations apparently promote lower levels of explanation and analysis. Evidence in support of the above from other workers is fairly apparent especially Berzonsky's (1969) findings for remote material. Berzonsky also found that causal situations of a malfunctional nature promoted more naturalistic responses than other situations. Similarly, his practical reversal situations also prompted more naturalistic responses. The work of Corrigan (1975) mentioned in Chapter 5 on children's understanding of reversed clauses and the level of operational thinking, may also be pertinent here. So, these findings of malfunctional or reversed situations promoting improved levels of causal explanation is supported elsewhere, as well as being a feature of the present investigation.

(e) Causal Thinking, Verbal, Demonstrational, and Psychomotor Modes

Causal demonstration which is represented in this investigation by the Water level test is a mixture of verbal and demonstrational modes, while the PCTB is purely verbal. The results of inter-correlational treatment (see Table No. 12a) shows that only the familiar initial causal component has any relationship with this form of causal demonstration and this is a negative relationship. The nature of this negative relationship being, that the generally higher levels of causal explanation for the familiar items was matched by a poor level of causal explanation when a demonstrational mode was employed. It may be, that where causal situations are a mixture of verbal and psychomotor modes, the latter mode is having a distracting effect. Therefore, it can be concluded that the null version of Hypothesis 7, of no relationship existing between appreciation of causal situations presented in a demonstrational mode, and those in a purely verbal mode is for the most part upheld. No significant relationship exists between verbal modes probing remote and malfunctional contexts, but a significant relationship exists for familiar contexts. However, in the latter case the relationship is a negative one, and is only just significant at $- .255$ $p < 1\%$.

The mainly psychomotor activity of the bicycle drawing exercise was compared with the various components making up the PCTB. The null version of Hypothesis 8, of no relationship existing between the appreciation of causal situations eliciting mainly psychomotor responses, and those eliciting purely verbal responses is upheld. This conclusion is at variance with the findings of Jahoda (1969), and more recently Inhelder and Piaget (1973) on drawing, remembering and understanding causal situations(see Chapter 3.) However, it must be pointed out that in this investigation, although the bicycle mechanism is an example of a well known causal situation, it is not one according to teachers at the experimental school, that many children are called upon to perform. In other words, it represents an instance of a familiar causal item, but a relatively unfamiliar psychomotor mode, which could therefore be compared as a general psychomotor skill to other causal measures.

It is clear, that the findings of both demonstrational and psychomotor modes in the context of causal situations, has implications for their use in an educational context and will be discussed briefly in Chapter 12.

(f) Causal thinking and the appreciation of other notions of Causality

In Chapter 2, the various conceptions of causality were discussed at length, and in devising instruments for this study, it was decided to construct a purely verbal battery of tests that reflected the generative view of causation. This is the PCTB. However, also in Chapter 2, alternative causal notions were discussed. The causal reasoning tests attempt to encapsulate some of these additional notions. It was hypothesised that as both the PCTB and Causal Reasoning tests were related to the same notion i.e. Causality, that children's performance on both would be positively related. However the results of the inter-correlation matrix (see Appendix D_3) upheld the null version of Hypothesis 9, that no relationship exists between the appreciation and analysis of causal situation as measured in the PCTB, and children's performance on the causal reasoning and causal problem solving tests. It is clear therefore, that the PCTB is tapping another facet of causal thinking, and one which is best assessed through a purely verbal mode. The causal reasoning tests, which probe a variety of causal processes e.g. retroaction, causal ground etc. and which were assessed by a mixture of modes, clearly taps more practical causal abilities.

The results of the Varimax Rotation (Table No.18) lends support to this contention. The practical emphasis of the school science curriculum, (mentioned in Chapter 7 page 149) to which the children investigated in this study are exposed, may be a contributory factor in interpretating these results. Finally, differences exist not only between children's performance on the PCTB and other measures, but that the results in Table No. 12 show differences within the battery. The negative relationship between initially appreciating a causal phenomenon, and subsequently analysing it in terms of plurality, probability and logico-causal deduction, indicates the inner complexity of causal thinking. These results also show, that logico-causal thinking is a special ability shedding considerable doubt on the "kinship view" of causal and operational thinking advocated by Piaget (1972).

11.1.2 Assessment of the findings relating to selected factors affecting children's causal Thinking

Two main extraneous factors were considered in the formulation of the second research problem. The first one, was the role of incidental or informal influences (which also was considered as a dependent variable being one of the causal components) and secondly, the role of a more structured influence which was the teaching of a specific item included amongst the remote types of stimulus material. However, due to organisational difficulties arising out of changes in the school timetable, it was not possible to set up control group. So that the hypotheses formulated for both extraneous factors, are working and not statistical ones.

(a) Causal Thinking and incidental experiential influences

From the results shown in Figure No. 10, it is clear that all the categorised sources of experiential or incidental information accompany children's appreciation of causal situations. Therefore working Hypothesis

(10), i.e. informal or incidental experiential influences are related to the appreciation of initial pluralistic and probabilistic causal components is supported. Figure No. 10 and Tables Nos. 9 - 11 also show, that the distribution of experiential sources is a function of the type of stimulus material, and therefore support is given to Hypothesis (11), i.e. informal or incidental experiential influences are related to the nature of the stimulus material used in the appreciation of initial, pluralistic and probabilistic causal components. Caution however, must be exercised in drawing too definite a conclusion concerning any substantial contribution the various sources are actually making to causal appreciation, and its subsequent analysis. However, it is clear that some sources are more in evidence than others for particular types of stimulus material and particular items. Pertinent here, is that children's appreciation of some malfunctional contexts e.g. death, train crashing, are accompanied by reference to particular media sources, such as TV for their information. As far as the author is aware, no previous work has been carried out on experiential sources and their contribution to causal thinking, so no comparisons can be made. However to probe the role of experiential sources, and whatever part they play in the development of causal thinking, would be an interesting area for further research.

(b) Causal Thinking and structured experiential influences

The "rain item" was taught to all children in their first year and haphazardly revised in their second. However, it was not possible to set up any controlled experiment to investigate the effect of teaching on children's appreciation of the origin of rain. Therefore, any conclusions that may be drawn can only be very tentative. However, examination of Table No. 10f shows that a large number of school sources were quoted for this item, but also, the distribution of response categories was concentrated at the "don't know" end, for all the causal components. On the other hand, for the initial causal component there is a band of category 3 and 4 type explanations. It is possible therefore, that teaching the origin of rain to these Ss, promotes only factual or embryonic causal explanations, as typified by category 3 and 4 responses respectively. What is more difficult to explain, is the large number of "don't knows"? The work of Bearison (1975) mentioned in Chapter 5 may need to be noted in this respect, where manipulating an environmental variable such as instruction had no marked effect on the acceleration of logical structures. However, unlike Bearison who also followed this up by a longitudinal study; in this investigation the effect of teaching may be having a "delayed effect". The results of the longitudinal data discussed in 10.4 page 301-, show that improved levels of causal explanation are recorded with 30% of Ss showing, progressive patterns and many of these patterns including category 1 and 2 responses. Therefore, the results for this section and the ones reported for the longitudinal data are more in line with the work of Biggs (1980), and Lawton (1977) on the effect of teaching (see Chapter 5 page 105). It may be concluded, that teaching probably influences the appreciation of causal thinking as measured here by the PCTB and in the context of the first guiding statement. However, a clearer picture emerges of the influences of teaching, when the longitudinal data for this item is examined (see Chapter 10.4) The data overall therefore, indicates that teaching may be having a "delayed effect" in that subsequent testings, show increased numbers of Ss registering improved levels of causal explanation.

However any support for Hypothesis (12) is bound to be very tentative in the absence of experimentation, employing controls.

11.1.3 Assessment of the findings relating to children's causal thinking and other abilities

(a) Causal Thinking and Language

The results concerned with this aspect of children's causal thinking are to be found in Table No. 13b, in which the significant correlation coefficients have been extracted from the correlation matrix. Completion and construction of sentences using selected causal connectives represented the main part of the language tests. These results show that the null version of Hypotheses (13) and (14) were upheld. That is, for Hypotheses 13, no significant relationship exists between children's appreciation of initial, pluralistic and logico-causal components, and their ability to complete sentences with causal connectives and for Hypotheses 14, no significant relationship exists between children's appreciation of initial, pluralistic and logico-causal components, and their ability to construct sentences with causal connectives.

The fact that the language measures correlated significantly with causal tests, which were mainly of a practical nature, suggests that the language required to assist the appreciation of causal situations as measured by the PCTB, requires more sophisticated linguistic processes other than construction and completion. The results indicate, that the generalising and abstracting tendencies and the readiness to explain causal phenomena as measured by the PCTB, are only just emerging in the majority of these Ss and that developing tests like those of Peel [(1975, 1975a)] may lead to more comparable measures.

(b) Causal Thinking and Relational Thinking

Causal thinking as measured by the PCTB does not relate significantly to tests of relational thinking. However, they show highly significant correlations with other causal measures which emphasize more practical causal situations. Clearly, the relational nature of the causal situations probed by the PCTB is of a different order than the more practical situations met with in the causal reasoning tests, and the electric light problem. Therefore it can be concluded that the null version of Hypothesis (15), is upheld i.e. no relationship exists between the appreciation of the initial, pluralistic and logico-causal components, and relational thinking.

(c) Causal Thinking and Judgemental/Verificational ability

The results of the correlation matrix (see Appendix D_3) show that no significant relationship exists between causal thinking as measured by the PCTB and the test for verification. In other words the null version of Hypothesis (16), was upheld i.e. no significant relationship exists between appreciation of initial, pluralistic and logico-causal components, and the ability to verify.

However, again those measures of causal thinking employing a more practical approach were related at a moderate level of significance (see Table No. 14b). It seems, that the purely verbal nature of the PCTB does not lend itself to the children's ability to verify and judge causal situations when verbally presented. However, ability to verify is, it appears related to causal contexts in which there is large degree of practical activity on the part of children.

(d) Causal Thinking and Creativity

Creativity was measured by giving the component of the Torrance Battery for Creativity dealing with cause. The results for these tests are found in Appendix D_{3_4} and shows that no significant relationship exists between children's appreciation of causal thinking as measured by PCTB and their performance on the Torrance tests. Therefore the null version of Hypothesis (17), is upheld i.e. no significant relationship exists between children's appreciation of initial, pluralistic and logico-causal components and creative ability. Owing to the lack of similar research, it is not possible to compare these findings. However, one might have expected a fairly marked relationship between creativity and causal thinking as conceived in this study. However, a possible explanation of the results for these tests, may be a more sensitive and appropriate measure of creativity is required?

(e) Causal Thinking and Standardised Measures of Achievement

Only three components of the Richmond Achievement Test correlated significantly with the PCTB but no value was above 0.3 ($p < .01$), but in excess of 0.255 ($p < .01$) the level of significance used in this study. This indicates that although significant, only a weak relationship exists between language usage, mathematical concepts, mathematical problem solving and causal thinking as measured by the PCTB. However Hypothesis (18) is partly upheld. That is, children's appreciation of initial, pluralistic and logico-causal components is related to children's performance on standardised achievement tests, but only those measuring mathematical problem solving, appreciation of mathematical concepts and language usage. The fact that even a weak but significant relationship exists between these particular Richmond tests and PCTB, gives further support to the idea that nature of causal thinking as probed by the purely verbal PCTB is different from that of other causal measures used in this study.

(f) Causal Thinking and ability grouping

The results of Factor analysis employing a Varimax Rotation showed that 5 factors emerged with eigenvalues over 1. This treatment clarified considerably, the relative diffuseness of the groupings obtained from a Principal Factor Analysis. Factor 1 may be labelled a Linguistic causal relational Factor, in which high loadings were obtained for language completion, using causal connectives, causal reasoning, as measured by a series of causal reasoning tests, and relational thinking. It can be concluded therefore, that the mixed practical and verbal nature of causal thinking, as probed by causal reasoning tests and the causal problem solving electric light test, is clearly a feature of the performance of the children tested in this sample. The purely verbal nature of the PCTB, and the causal thinking it measures, is not a dominant mode of causal thinking here. This somewhat more abstract nature of causal thinking as conceived in the componential view of causality, obviously requires a higher order of causal thinking and is not a characteristic feature of this sample. This view is to some extent supported by the generally large standard deviations on measures of achievement included in the Richmond test, reflecting a skewed distribution to the lower end of the range of scores (see Appendix D_2). It is also reflected in the results obtained by other measures, such as causal connectives test which relates very significantly to more practically contrived causal situations, than the more abstract situations tested by the PCTB.

Factor 2 may be labelled a General achievement factor in which there are high loadings on mathematical ability, while factor 3, a Causal Creativity factor. It is only when we observe factors 4 and 5 that this sample exhibits an appreciable variance for their performance on the PCTB. Factor 4 has significant but different value loadings on the initial causal component for all three types of stimulus. Therefore, this factor may be labelled an Initial Causal component factor while factor 5 a Causal Plurality factor, again with significant but different value loadings for all three stimulus materials.

11.1.4 Assessment of the findings Relating to children's causal and operational thinking

(a) Piagetian stages of Causal Thinking

The initial causal component of the PCTB, is the nearest form of causal thinking studied in this investigation, that can be compared to the rationale and procedures that Piaget (1930) used in his work on causality. Therefore, reference will be made only to this component. From the results reported in 9.1.1 and illustrated in Figure No. 6, it is clear that the majority of responses registered by this sample are distributed between response categories 1 - 4. In other words, naturalistic or mechanical to logical-deductive type answers are the norm for this age group. This means that most children are firmly established in Piaget's causal period 3 (see Table 1 Chapter 3). Nevertheless, contrary to Piaget's findings we still find elements of pre-causal thinking in some children's responses, especially when the causal situation is one of a remote nature. Therefore, we may conclude, that most responses given by children from this sample to initial causal components are of a mechanical type, but some Ss also register more advanced forms of logical explanation. However, the hierarchical categorical system used in this study shows that most responses are of a simple mechanical nature, although some explanations are registered at a level beyond an embryonic relational form, as categorised by response category 2. Therefore, Piaget's findings have been confirmed and so working Hypothesis (19), is supported i.e. the appreciation of initial causal components are related to Piagetian norms for causal appreciation, and for the age range studied here. Owing to lack of similar research it is not possible to compare with other Ss of the same age, the results of these children's performance on the causal explanatory categories. However, the low incidence of higher explanatory categories may be feature of this sample's abilities. Scores as measured by standardised achievement tests indicate a skewed distribution to the lower end of the normal distribution reflecting poor overall level of performance. Further support for this contention comes from the relatively low numbers of children of this age who conserved substance and weight.

(b) Causal Thinking and Operational Thinking

In Chapter 3 page 74 Piaget's (1974) more recent work on understanding causality was discussed. In the course of the discussion, it was shown how Piaget predictably argues for the importance of operational processes such as transformations, compensations etc. which contribute to the fabric of causal thinking in the child. The results of this investigation however, show that the comparisons between children's performance on conservation of substance, weight, area and volume are far from giving whole hearted support to the above contention. Examination of the F values in Table Nos. 16 and 17 for familiar, remote and malfunctional stimulus material in the initial causal and logico-causal components, show few significant values. Where significant values are recorded, they appear in the context of malfunctional causal situations and are for substance; (initial causal components) or volume and substance notions (logico-causal components). In the case of familiar and remote material, significant F values are recorded for volume conservation, the familiar for the logico-causal component, and the remote for the initial causal component.

From these results, Piaget's contention of a close interaction between Causal and operational thinking is only partly supported. It appears that comparisons between area and weight conservation, and causal thinking provides only qualified support for Piaget's contention. On the other hand, significant F values for substance and volume conservation especially in malfunctional causal situations, provides the strongest support and where the highest F value for the logico-causal component with volume (see Table No. 17) is at the 1% level of significance df 3,101. One can only conclude from these findings that the relationship between causal and operational thinking is not quite the interactive process we are lead to believe by Piaget (1974). However, the fact that volume conservation figures more prominently than other conservational notions in its relationship with logico-causal components of the PCTB provokes further serious consideration of the abstract nature of causal thinking as measured by the PCTB. Therefore the null version of Hypothesis (20) That appreciation of initial causal components is not related to operational thinking as expressed in children's performance on conservational notions such as that of substance, weight, area and volume and Hypothesis (21) That appreciation of logico-causal components is not related to operational thinking as expressed in children's performance on conservational notions such as conservation of substance, weight, area and volume are only partially rejected. An interesting point which arises from the research in this area is the nature of malfunctional causal contexts and their comparison to both concrete and formal operational thinking.

11.1.5 Summary - Assessment of the main trends arising out of the study of Guiding Statement 1

Briefly summarising, the nature of causal thinking for this sample of middle school children is characterised by a greater appreciation of practical causal situations. Causal appreciation as measured by the PCTB, which promotes through a purely verbal mode, a more abstract appreciation and analysis of causal situations is much less of a feature. This may be due to the level of the children's development at the time of testing. To discover whether such causal thinking might become a more established feature, the children would need to be tested longitudinally and this is the raison d'etre for investigating Guiding Statement 2.

It appears that the more "pragmatic" nature of causal appreciation as measured by causal reasoning, causal problem solving tests, relate very significantly in some cases, to language and relational ability. While causal appreciation as measured by the PCTB stands as a separate causal ability. Measures of general ability and causal creativity, while relating to some causal measures are also by and large separate.

In comparing the results of this study with Piagetian norms established by other workers, most children are operating at Period 3 of Piaget's developmental framework for causal thinking. As to the process of operational thought and its interaction with causal thinking, the evidence reported here does not support the Piagetian position whole heartedly. Only volume and substance conservation in different contexts and with different causal components can be said to show any comparison, and these comparisons are at fairly high levels of significance.

11.2 Assessment of the findings relating to the longitudinal study of causal thinking by middle school children

In the summary of main trends that arose from the study of Guiding Statement 1 above, it was mentioned that children tested in this investigation showed a greater appreciation of more practical causal situations than the one measured by the PCTB. It was further noted that this could be a feature of the children's development at the time of testing, and that a longitudinal study of the type of causal situations measured by the PCTB, might reveal more about the development of this form of causal thinking. This observation was among several that prompted the writer to explore this particular area for a longitudinal study. Originally, research question 5 (see page 142) included an investigation of all components in the PCTB and in fact was actually undertaken. However, only the results of the initial causal component is discussed here, due to limits on time and space.

11.2 Assessment of the findings relating to the longitudinal study study of causal thinking by middle school children.

The conclusions reported in this section will be presented under the following sub-sections:

11.2.1 Conclusions relating to a Global Analysis of the longitudinal data,

11.2.2 Conclusions relating to Modal Pattern Analysis (MPA),

11.2.3 Summary - Assessment of Main Trends arising out of a study of Guiding Statement 2.

The research problems and their related hypotheses will be referred to in the sub-sections. However, as this part of the investigation is mainly exploratory and also deals with a longitudinal approach, principally interested in the development of qualitative mental structures, the hypotheses are mostly working ones rather than rigorous statistical statements. Furthermore, one of the major problems already discussed in Chapter 5 page 115 is the lack of adequate statistical treatments to accompany the analysis of this type of qualitative data (see Versey 1980).

11.2.1 Assessment of the findings relating to a Global Analysis of the Longitudinal Data

(a) Descriptive Statistics

Examination of Figures 13, 14, 15 show that the quality of children's appreciation of initial causal components does change over time. The change tends to be one of progression especially, for all familiar and malfunctional types of stimulus material, but to a much lesser extent for remote items. Therefore Hypothesis (22), that children's explanation of an initial causal component, as measured by a hierarchical categoric system, changes over time in an upward direction is supported.

In taking a more detailed look at the three types of stimulus material and particularly individual items, a further picture of children's development of causal explanatory behaviour is obtained. From Figure No. 13, Chap.10, it is obvious that familiar items all promote a consistent and fairly substantial measure of progressive change. This is followed by a measure of no change. Malfunctional stimulus material follows fairly similar patterns, (see Figure 15), but the number of Ss registering progressions, are larger than those for familiar materials. Once again, the feature of the malfunctional context promoting a higher quality of performance, seems to be a global feature, even along the longitudinal continuum. Remote stimulus material however, provides a less clear series of trends and from Figure No. 14, the hierarchical categoric system of explanation, is more item specific than is the case for familiar and malfunctional material. It appears that origin of night and lightning, promotes linear patterns for the majority of Ss. Space and Dream, marginally promote more erratic patterns while cloud and rain, both items subject to some teaching exposure promotes more progressions and therefore may not be entirely the result of remoteness.

It can be concluded therefore Hypothesis (23), is supported i.e. children's explanation of an initial causal component, as measured by a hierarchical categoric system changes over time, and is a function of the nature of the stimulus material. That is, familiar and malfunctional situations promote more progressive and linear patterns, while remote material, promotes a greater variety of patterns which are more item specific.

(b) Two-Way Anova Mixed Design and Pearson Correlation Treatments

A major problem concerning a longitudinal study of Piagetian cognitive development, is the paucity of adequate statistical treatments for the data. This subject has been discussed at length by Versey [(1974, 1980)]. He developed an elegant method of multi-dimensional scaling in the treatment of his data. However such a technique, and others suggested later by Plewis's [(1980, 1980a)] (mainly the use of a Markov chain), proved unsuitable for any large scale treatment of this data. Owing to an insufficiently large sample, and the application of a hexacategoric scoring system, the use of such treatments had to be ruled out. However, in addition to a descriptive statistical analysis as a means of providing a global view of the data, it was decided to employ a repeated measures design. Table Nos. 19 and 19a show the F values obtained by the application of a Two-Way Anova mixed design. This is reported in Versey (1980a), and as a single factor repeated measures in Winer (1971). As a result of the Two Way Anova Mixed Design treatment the null version of Hypothesis 22, i.e. no changes occur, in children's explanation of initial causal components, as measured by a hierarchical categoric system over time in an upward direction is rejected at the .01 level df 2,156.

Similarly, the null version of Hypothesis 23, i.e. no changes occur in children's explanation of an initial causal component as measured by a hierarchical categoric system, and is not a function of the nature of the stimulus material is rejected at the .01 level df 2,156.

From the results we may conclude the following:

(a) the trends indicated by the high F values show a large degree of variance for both between and within Ss sources,

(b) that both sources of variance are differentially and significantly related to the nature of the stimulus material e.g. familiar, remote etc.,

(c) that significant sex differences are reflected in the large between Ss, F values and in which boys show a greater tendency for progressive change,

(d) that the statistical treatment gives only a superficial view of the changes that are taking place. This is particularly obvious when the variety of modal patterns are examined in Appendices E_2, E_3 and E_4,

(e) the comparatively lower F values and highish correlation coefficients derived from the performance of Ss on the Richmond Tests administered in their first and second years (see Appendices E_5 and E_6), is in contrast to the high degree of variance that a study of the same qualitative Piagetian type tests reveals, when studied on three discrete occasions with the same sample.

From (d) and (e) above, we can conclude that in answer to research question 7 (no hypotheses given with this question - see Chapter 6) <u>the more sensitive nature of the PCTB instrument as developed in this investigation, reveals much more variance in childrens developmental processes and, that children's achievement as measured by standardised tests mask considerable developmental patterns</u>. Whether, the same comparison would hold if notions other than causality were used as the subject of qualitative measurement, is a question for further research. It is also interesting to note that the recent research of Hindley and Owen (1979) (referred to in more detail in the next section) employed a visual system of classification to represent their data. It might therefore be suggested, if successive testing of this sample using the Richmond Achievement Test over a comparable age span to that reported by Hindly and Owen, similar visual patterns of change might be found. Such patterns that might emerge, paralleled with patterns derived from the Piagetian type tests i.e. PCTB, could give a more informed and valuable profile of these children's cognitive development!

11.2.2 Assessment of the findings relating to Modal Pattern Analysis (MPA)

The work of Hindley and Owen (1979) post-dates the research carried out in this study. However, these workers have also devised a visual classification to analyse their longitudinal data. The visual patterns were obtained by drawing graphs of standard score against age. After a thorough analysis of the shape of the curves, seven patterns were agreed upon. The efficiency of the classification was tested using the polynomial equation of each group and this was contrasted with those of other groups. Mention is made of this work, for it is the only research the author has discovered which comes close for comparison. However, it should be pointed out that while Hindley and Owen's work aims to analyse individual patterns of children's development like the present study, they are treating quantitative data as opposed to qualitative categoric data, as in this case. Furthermore, the age span is much greater. Nevertheless, some of the findings reported by Hindley and Owen have some significance for the results of this study, and will be mentioned in parts of the discussion. A discussion of each modal pattern now follows.

(a) Linear Patterns

From the results presented and discussed at length in Chapter 10, it is clear (a) that the frequency of linear patterns of explanatory behaviour are fairly substantial; (b) that this type of pattern is related to the nature of the stimulus material. It appears that familiar material generally promotes one or two word explanations (category 4) as well as causal explanations having traces of relational thinking (category 3). Remote material elicits large numbers of Ss to give pre-causal explanation (category 5) or "don't knows" (category 6). Malfunctional material clearly promotes more relational responses (categories 2 and 3). Linear patterns represent no change in the way children explain causal phenomena, this may be because the children, for the period of this study at least, have arrived at a certain level of knowledge about a causal situation. Until some maturational, or environmental variable such as intervention, incidental experience etc. influences further change, no appreciable difference will emerge. The role of experiential factors investigated in this study as part of the PCTB tends to support the contention, that experiences plays a part in linear patterning, as invariably, it was related to the same experiential source registered at each testing. This support illuminates further, the nature of the environmental variables that may be influencing cognitive development of individuals, and which received some attention by Hindley and Owen (1979) in the discussion of their research. Finally, sex differences were recorded for most of the linear patterns, with boys registering higher categories of explanation than girls.

(b) Progressive Patterns

As expected, the greater number of Ss exhibited some form of progressive change, a finding that Hindley and Owen also report for their own type of data. Plateau and lag patterns, are clearly most frequent while gradients are much less so. The patterns 4 - 3 - 3, 3 - 2 - 2 and 4 - 2 - 2 are the most common plateaus irrespective of the type of stimulus material. However, boys give more 3 - 2 - 2 patterns than girls and malfunctional material promotes more 3 - 2 - 2 and other higher forms, than familiar and remote material. We may conclude, that for the progressive appreciation of causal situations, an early improvement in the level of causal appreciation is followed by a consolidatory period, and that girls consolidate at a lower level of explanation than boys. However, the nature of the stimulus material appears to play an important role in determining the level of explanation.

Lag patterns also, are a marked feature of these children's progressive explanatory changes and appears to be related to the nature of the stimulus material. Such patterns are more frequent for familiar and malfunctional causal situations and less so for remote. Dominant pattern types are 4 - 4 - 3 and 3 - 3 - 2 respectively, with girls giving more of the former than the latter. The sex differences occurring for this and the other progressive pattern types, are no doubt contributing to the large F values discussed in Chapter 10 (see Table Nos. 19, 19a) and section 11.2.1 of this chapter. The lag pattern is one which reflects a later climb to a high explanatory category, after a period of consolidation. It makes therefore for a slower form of developmental change. It may be that as more lags were registered for familiar items, this type of change is influenced by such items?

Gradient patterns are clearly not a feature of these S's development of causal thinking. Where gradients did occur, they were registered more by boys than girls and more with remote material than with other forms. A gradient pattern could be considered as the typical Piagetian developmental sequence. However in trying to explain why so few subjects register this type of change, the answer may lie in the S's "entering knowledge" i.e. the interest, experience and information he has already about a particular item (although maturational levels are also likely to be involved). From Table No. 8 Chapter 9, it is clear on the basis of the "don't know" criterion for item difficulty, the entering knowledge varies considerably for the different items included in the PCTB. Therefore, a longitudinal study will reflect how this entering knowledge develops or not. The evidence from the results shown in Appendix E_2 E_3 and E_4, indicate that S's level of entering knowledge for remote stimulus items gave a fairly reasonable scope for improvement, and this was clearly registered by boys more than girls, whose interests and experience is partly reflected in the items of the PCTB e.g. space ship movement. The most common gradient type is 4 - 3 - 2, the third test indicating a level of causal explanation more reminiscent of boys than girls.

Before leaving progressive change, mention needs to be made about the role of "practice effects". In the present study the results of the control Ss by and large indicate that practice effects are not serious confounding influences. However, the reader is referred to the results of individual items (Appendices E_2, E_3 and E_4), for such effects are more a feature of some items than others.

Nevertheless, that practice is likely to be involved as a factor in most progression cannot be ruled out, but its extent appears from the evidence to be limited.

(c) Regressive Pattern

Regression is clearly a feature of the results reported for this study and unlike the research reported by Almy et al (1966) and Versey (1974) the regression here is "pure" i.e. Ss did not change their explanatory status to a former higher level. The "vacillations" discussed by Almy and Versey are considered here as Erratic patterns and will be discussed in (d). However, in accounting for their results the presentation of the stimulus and particularly the wording of questions have been given as possible reasons. However, in this study the question wording was strictly adhered to throughout the three tests, and the mode of presentation was purely verbal. However, the nature of stimulus material used in the test (i.e. PCTB) shows from the results, that remote material elicits the largest number of regression patterns. In examining more closely the exact nature of the regression for remote material, 5 - 6 - $\boxed{6}$,* 4 - 6 - $\boxed{6}$* and 3 - 6 - $\boxed{6}$*; all "don't know"/6- end points is a recurring feature. While wording and presentation cannot be ruled out as possible factors, it is more likely that the nature of the stimulus material may also be influencing regression. On the other hand it is suggested that mnemonic, motivational as well as methodological factors need to be seriously considered as additional influences and furnish interesting areas for further research.

However, although the results are not strictly comparable to Piaget's earlier longitudinal studies, and more recently Piaget's and Inhelder (1973) longitudinal research on causal thinking and memory, the results of <u>this</u> study show that regression <u>is</u> a feature, and one that is a result of several factors of which the type of stimulus material may be playing an important role? If the type of regression met in this investigation is a consolidation period, "rending" the situation more intelligible, rather than a regression, (Piaget and Inhelder (1973)), it would be interesting to investigate how long it might take for Ss to return to their former status, as the period of testing here was 14 months while Piaget and Inhelder's was six?

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* Boxed for emphasis.

Finally, Dudek and Dyer (1969) specifically investigated the incidence of regression using 9 Piagetian type tasks including causality, and analysed their results in stages and sub-stages. Stage 2 for any concept is intermediate and unstable. A true regression would be shown, if there was a 3 to 1 reversal. For their sample of 64 children of kindergarten age, tested 4 times at yearly intervals, only 1% of a possible 10.4% regression was recorded. On the basis of this low % of regression, Dudek and Dyer suggest their findings support Piaget's theory of developmental stages, and that personality factors may account for the regression phenomenon. It might well be the case, that had the present study been extended over two or three more years, the number of Ss indicating regression might also have been reduced? However, what role personality factors may play would be another interesting research area to follow up?

(d) Erratic Patterns

From the results discussed in Chapter 10, it can be concluded, that erratic patterns of causal explanation are a marked feature of these children's causal thinking. The results in Appendix E_2, E_3 and E_4 are testimony to the variety of ways in which even over a 14 month period, children fluctuate in their level of causal explanation. Erratic patterns or "vacillations" are indicators of the dangers of applying too rigid a conception of stage, or other developmental category to children's mental development. In attempting to account for these patterns; the influences mentioned in the paragraph on regression may also apply. Clearly, the nature of remote stimulus material promotes a large measure of diversity, whether it is a symmetrical, asymmetrical, apical or depression pattern. However, it is suggested that mnemonic factors may be having some influence on the occurrence of these patterns. Nevertheless, it was beyond the scope of the present study to include an investigation of memory processes, but clearly they are important and could form the basis of further research into longitudinal studies of cognitive development.

11.2.3 Summary - Assessment, of the Main Trends arising out of a study of Guiding Statement 2

The nature of change associated with children's causal thinking as studied in the context of guiding statement 2, reveals that progression to higher levels of causal explanation is a marked feature of many children's performance. Further, that this progressive change appears to be partly a function of the nature of the stimulus material. Familiar and Malfunctional stimulus material promoting more progressive change than remote situations. However, examination of the detailed modal patterns of change i.e. plateau, lags etc. reveal further information about groups or individuals, in the way they explain causal situations over time.

The treatment by a two way Anova Mixed design showed at a global level, the large amount of variance that exists between boys and girls and also between the three types of stimulus material. While the highly significant F values reflect the level of variance, it masks individual and small group changes which was exposed by the Modal Pattern Analysis (MPA). The work of Hindley and Owen (1979), using quantitative data have attempted to present visually, the extent and nature of developmental change. Further research in developing these visual techniques, and possibly devising a dovetailing of the patterns derived from a quantitative and qualitative assessment of the data, could provide valuable "cognitive developmental profiles" for individuals, and small groups of individuals. However, the development of cognitive development profiles still requires a substantial amount of research relating to statistical treatments of the data, and in which studies using multi-dimensional scaling [e.g. Versey (1974)] and the possible application of modified Markov chain treatments [e.g. Plewis (1980)] could form a sound basis from which to proceed.

Finally, Modal Pattern Analysis (MPA) an essentially descriptive treatment, revealed many interesting and varied trends i.e. linear, progressive, regressive and erratic patterns with varying degrees of frequency. Linear patterns seem to be closely related to experiential factors. Progressive patterns, were recorded by over third of Ss with plateau and lag patterns the most frequent. However, what might be considered as the more typical developmental pattern a gradient, is not a feature. Both girls and boys show plateaus and lags, but many more boys showed gradients. The detail of pattern types also showed sex differences, with more girls giving lower explanatory levels than boys. The various Modal Pattern types appear to be a function of the stimulus material. Remote causal situations promote more gradients, while mal-functional contexts elicit higher categories of causal explanation in lags and plateaus.

Several factors are suggested as possible explanations for these results, apart from the obvious one of the nature of stimulus material; a S's "entering knowledge" of a particular item, practice effects and maturational process are probably involved. Further research would however, be required to determine the exact effect of these factors, and the particular conditions in which they would bring about the greatest possible change.

Regression is a feature of some children's performance and while other workers have detected a version of the phenomenon (i.e. vacillation) previous research seems not to have discovered the extent of the trend met here i.e. pure regression. Remote material appears to promote more regression than other causal contexts, and it is registered by girls more than boys. The pattern types reflect lag patterns with drops from 5 - 6, 4 - 6 and 3 - 6, which are the most frequently encountered. While wording, experimental presentation and personality characteristics have been put forward by previous workers as possible causes for regression, it is more likely that mnemonic, motivational and stimulus non-familiarity may be more crucial. However, the study of regressive factors is clearly an interesting and essential area for future research into cognitive developmental processes.

Finally, erratic patterns were also showed by a substantial number of Ss, and the results show the large diversity which children displayed in the way they vacillated over the 14 month testing period. While methodological factors e.g. question wording, presentation etc. as well experimental error etc. cannot be ruled out as possible sources for these patterns, again the nature of stimulus material and probably mnemonic factors are also operating. As in the case of regression phenomena, the field for further research is wide open. Although the case study items and individual S profiles have not been included in this chapter, an examination of the trends shown in these studies, indicates the clarity and as well as the diversity of change that longitudinal studies of children's development presents.

11.3 Summary of the main findings and conclusions

11.3.1 Findings and Conclusions Relating to the nature of children's causal thinking

(1) When children are capable of initially appreciating causal phenomena they resort to explanations which are hierarchical.

(2) The children tested in this study had a mean age of 115 months and registered various explanatory categories from 1 - 6. This indicated, that a hierarchical system of causal explanation is a feature of the age of children who were studied here.

(3) The appreciation of initial causal components is differentially related to the nature of stimulus material which constitutes a causal situation. Malfunctional stimulus situations tend to promote higher explanatory categories i.e. 2 and 3. Familiar situations, mostly elicit one or two word explanation, i.e. 4, whereas Remote stimulus, often promote pre-causal explanations and large numbers of "don't know".

(4) Explanatory categories registered for individual items, reflect the general findings for the type of stimulus material in which they are included. However, unique features are also present such as high incidence of upper categories of explanation for bicycle mechanism, large numbers of pre-causal and "don't knows" for lightning and origin of night etc..

(5) The nature of the stimulus material, also relates to the extent children analyse causal situations. Analysis of causal plurality, probability, and logico-causal components, is promoted to a greater extent by malfunctional situations, followed next by familiar and lastly remote contexts. It is clear, that the malfunctional causal context, is one that stimulates a higher level of causal thinking. This malfunctional feature has been reported by other workers, and clearly has educational implications.

(6) No positive relationship exists between children's causal thinking as measured by the purely verbal PCTB, and their performance on a causal demonstration represented by the water level test. Only a barely significant negative relationship exists between children's appreciation of the familiar causal components and their performance on the causal

demonstration. This may be due to the distracting nature of demonstrational cues, interfering with the expression of better quality explanations. Such quality explanations were more a feature of children's performance on the verbal PCTB.

(7) No significant relationship exists between S's appreciation of other causal components and causal demonstration.

(8) In comparing the performance of children on the mainly psychomotor activity of bicycle drawing, with various components of the PCTB, no significant relationship exists. It appears therefore, that causal appreciation employing purely verbal modes and a familiar causal psychomotor activity have little in common. These findings on the demonstrational and psychomotor modes of causal thinking, clearly have educational implications raising questions about the selective use of such modes in the teaching of science.

(9) No significant relationship exists between the appreciation and analysis of causal situations as measured in the PCTB, and children's performance on tests of causal reasoning. This may be related to the fact, that the former situations are verbally presented, while the latter are a mixture of verbal and practical presentations. However, that different causal notions are also included in the latter tests, and therefore tapping different abilities vis-a-vis causation, cannot be ruled out. This is supported to a large extent by a high loading on factor 1 of the causal reasoning measure.

(10) A negative relationship exists between initially appreciating a causal situation and its subsequent analysis in terms of pluralistic, probabilistic and logico-causal thinking. This suggests that such thinking is not only complex but sheds considerable doubt on Piaget's view on the "Kinship" between causal and operational thinking. These results are further reinforced in 11.3.4; findings No. 29 and 30.

11.3.2 Findings and Conclusions relating to selected factors affecting children's causal thinking

(11) The categories of the experiential causal component which indicate various sources of informal or incidental information, accompany children's appreciation of causal situations as measured by the PCTB.

(12) The distribution of experiential sources is a function of the type of stimulus material; such as familiar and malfunctional stimulus material in its appreciation by children, is accompanied by predominantly "self" and "familial" sources. Children who appreciate some malfunctional causal situations, also gave substantial numbers of media sources especially television.

(13) Caution however must be exercised, as to the exact nature of the relationship between experiential source, and the mechanism of causal appreciation and analysis. Further research would be required to establish to what extent the experiential source contributes to levels of causal explanation and causal analysis.

(14) The "rain item" was the only item from the list of 18 stimulus items to receive specific instruction in class during this investigation. No valid conclusion can however be put forward, because difficulties of timetabling arose during the investigation, and prohibited the setting up of a controlled experiment. However, it appeared that for this item the largest number of school sources were cited for the experiential component. Whether this fact is related to the large number of "don't knows" and a fairly solid band of response categories 3 and 4 registered for this sample, is an open question? The longitudinal data collected later in the study indicates perhaps a "delayed effect" is operating for this item, as the number of "don't knows" fell substantially, with a simultaneous increase in progressive explanatory patterns.

11.3.3 Findings and Conclusions relating to children's causal thinking and other abilities

(15) No significant relationship was recorded between either the ability to complete and construct sentences with causal connectives, and the ability to appreciate causal situations as measured by the PCTB. This result may be due to the fact, that causal thinking as measured by the PCTB, requires a more sophisticated use of language construction over and above the use of causal connectives, and more in line with the abstract nature of causality as conceived in this study.

(16) Highly significant relationships were however, recorded between the ability to complete and construct sentences using causal connectives and more practical causal measures such as causal reasoning and electric light tests. Clearly, a practical element incorporated into causal situations requires the ability of Ss to use causal connectives in their explanation of the causal mechanisms.

(17) No significant relationship was recorded between the ability to appreciate causal situations as measured by the PCTB and children's performance on relational tests. However, a highly significant relationship rho $0.9, p < .01$ was recorded between performance on the causal reasoning tests and that on the relational test. A lesser significant relationship was recorded for children's performance on the electric light problem rho $0.6, p < .01$. It appears therefore the appreciation of causality with an emphasis on practically contrived situations is strongly related to the ability to appreciate relationships as probed in this test of relational thinking.

(18) No significant relationship was recorded for the performance of children on the test for verificational or judgemental ability, and their appreciation of causal situation as measured by the PCTB. However a weakly

significant correlation was recorded for children's performance on the causal reasoning tests. Again, the practical nature of several parts of the causal reasoning test, may account for this result.

(19) No significant relationships were recorded for children's appreciation of causal situations as measured by either the PCTB or other causal tests with the Torrance Test for Causal Creativity. Causal creativity is clearly a separate ability, a finding that was borne out in the Varimax rotated solution of the factor analysis treatment.

(20) Weakly significant relationships were selectively recorded between childrens performance on language usage, mathematical concept appreciation, mathematical problem solving (all Richmond Test measures), and appreciation of causal situation as measured by the PCTB. Initial causal components of familiar, remote and malfunctional situations are all related to performance on mathematical problem solving. This finding gives some support to the contention, that the PCTB is tapping a more abstract form of causal thinking.

(21) The factor analysis treatment using a Varimax rotation showed that 5 extractable factors emerged with eigenvalues greater than 1. This clearly indicates that causal thinking encompasses groups of abilities.

(22) Factor 1 accounted for 30.5 of the variance in which high loadings were recorded for linguistic, causal reasoning, causal problem solving and relational abilities. It is obvious that this factor was one reflecting the practical features of causal situations for this sample. The factor may be labelled a linguistic causal relational factor.

(23) Factor 2 accounted for 23.9% of the variance and a factor in which high loadings were recorded for the Richmond achievement components. Especially high loadings were registered for the mathematical problem solving and mathematical concept components. This factor may be labelled a general Achievement Factor.

(24) Factor 3 accounts for 16.5% of the variance and contains a highly significant cluster of coefficients for causal creativity as measured by the Torrance Test. This factor is clearly a separate causal creativity factor and may be labelled i.e. a Causal Creativity factor.

(25) Factor 4 - Initial Causal Component and Factor 5 - Causal Plurality Factor account for 14.1% and 6.8% of the variance respectively. For this sample of British middle school children, causal appreciation as measured by the PCTB is not a strong feature of their causal thinking. This may be due to the fact that most of these middle school children found the purely verbal causal situations too abstract to grasp, when compared to their much better appreciation of more practical causal situation. The practical emphasis of the school science curriculum may be a factor responsible for these results.

11.3.4 Findings and Conclusions relating to children's causal and operational thinking

(26) Most responses given by children in this sample to initial causal component were of a mechanical nature, with some Ss giving more logico-deductive explanations. This supports Piaget's findings for children of this age group.

(27) However, the sensitive categorical system devised by the author showed the level of mechanical and other forms of explanation put forward by these Ss. The level generally reflected, one or two word explanations, or embryonic relational type causal explanations. High levels of causal explanation were not a marked feature.

(28) Poor levels generally, of causal explanation possibly reflects the developmental status of the child, or their level of ability as measured

by standardised achievement tests. Therefore, a need for longitudinal studies of causal explanation arises to trace the patterns of development in causal explanation.

(29) Support for Piaget's contention that a close relationship exists between operational thinking (here measured by tests of conservation) and causal thinking is only partial.

(30) Significant values are recorded for volume and substance and these are mainly in the context of malfunctional and familiar causal contexts, and in initial and logico-causal components. However, the significance level is fairly high ($p < .01$, df 101) for these comparisons, and so lends some support to the Piagetian position, vis-a-vis causal and operational thinking.

(31) The possibility that the nature of causal thinking as measured by the PCTB promotes a higher level of abstraction, than do tests of a more practical nature, is given some support by the strongly significant relationship that exists between children's performance on volume conservation and logico-causal thinking.

(32) The peculiar nature of malfunctional causal situations once again provides further interesting findings in the context of Piagetian conservational measures. For both initial and logico-causal components, significant F values are recorded for <u>substance</u>, <u>and volume and substance</u> respectively. Clearly from what has been discussed elsewhere in this summary, more research into malfunctional contexts be they causal or otherwise, might reveal valuable information on the processes of intellectual development and which could have implications for educational practice.

11.3.5 Findings and Conclusions related to a Global Analysis of the longitudinal Data

(33) Children's appreciation of initial causal components changed over time and the change tends to be in an upward or progressive direction as measured by a categoric hierarchical system.

(34) Greater numbers of Ss register progressive modal patterns when the stimulus material used is malfunctional or familiar, while remote stimulus material appears to promote more diversified patterns. However, remote items that were affected by teaching, gave more progressive patterns, and so the relationship of level of experience and causal appreciation may be confounded by intervention. The hypothesis that children's explanation of initial causal components measured over time and is a function of the nature of the stimulus material, is however substantially supported for the most part.

(35) The null hypothesis that no changes over time are recorded when S's causal appreciation is measured by the PCTB with reference to initial causal component is rejected. The results show a high level of significance beyond the .01 level (df 78) when tested by a Two-Way Anova mixed design.

(36) However it is not possible to link the large amount of variance entirely to progressive change, but the results in Appendix E_2, E_3 and E_4 would indicate that progressive change accounts for a large part of this variance.

(37) Large between Ss difference also reflect sex differences, with boys registering more change and especially more progressive change than girls.

(38) Both between Ss and within Ss sources of variation are related to the nature of the stimulus material for the experimental groups. Remote material promotes more variation between groups; reflecting sex differences,

while malfunctional elicits more variance for within groups reflecting more the nature of the material. Therefore, the null hypothesis that there is no difference in childrens appreciation of an initial causal component when different stimulus materials are used, is rejected well above the .01 level of significance.

(39) The results of the Richmond Achievement Tests administered to the sample in their first and second years after treatment with a Pearson - Correlation and a Two-Way Anova mixed design showed changes, but that the qualitative data obtained from the PCTB showed a much greater degree of change. This is probably a consequence of the qualitative nature of the test and especially its sensitivity.

11.3.6 Findings and Conclusions Relating to the Modal Pattern Analysis of the Longitudinal Data

(40) Linear patterns of causal explanation are a marked feature of the children tested in this investigation, and the occurrence of the various pattern types is related to the nature of the stimulus material.

(41) Familiar material promotes in the main, category 4 type responses but with traces of relational thinking in the form of category 3 responses. Remote material elicits large numbers of pre-causal explanations (category 5) as well as appreciable numbers of Ss registering don't knows (category 6). Malfunctional material stimulates Ss to register higher quality explanations particularly category 2.

(42) Sex differences are a feature of linear patterning with boys generally registering higher categories of explanation e.g. category 2 and 3.

(43) The same experiential sources as probed in the PCTB seemed to be linked in many S's responses, with the same types of explanation for the initial causal component. This indicates a strong experiential influence in the formation of a linear pattern.

(44) Progressive patterns of change were registered by the largest number of Ss and this was an expected result. This finding is supported by other longitudinal research using IQ scores.

(45) It is suggested that further research combining the use of visual patterns of children's cognitive development based on quantitative and qualitative data would provide a useful cognitive developmental profile. Such a profile could furnish a more informative picture of small changes in an individual's development or group of individuals. However, the statistical treatment of qualitative data await further development of multidimensional scaling and use of probability measures such as the Markov chain.

(46) All three forms of progressive patterning were recorded,but plateaus and lags are more frequent than gradients. It appears that the nature of the stimulus material has an influence in the determination of the type of progressive change, although maturational factors may also be playing a role, the extent to which it is difficult to assess. Practice effects also need to be considered but the results show their role in progression is limited.

(47) Plateau patterns 4 - 3 - 3, 3 - 2 - 2 and 4 - 2 - 2 are the most commonly occurring irrespective of the nature of the stimulus material. However, girls register the lower levels of explanation.

(48) Lag patterns are more frequently registered for familiar and malfunctional contexts than remote ones. Dominant lag patterns are 4 - 4 - 3 and 3 - 3 - 2 respectively, with girls giving more of the former than the boys. Overall, lag patterns were more a feature of familiar contexts than for the other types.

(49) Sex differences registered for the various forms of progression pattern, probably contributes to the large F values as shown from the Two-Way Anova mixed design treatment of the data.

(50) Gradient patterns of progression are not a marked feature of causal thinking for the Ss studied in this investigation. When gradients were recorded, more boys gave them than girls and generally were characteristic of the appreciation of remote contexts. A tentative explanation for this finding may lie in the nature of a Ss "entering knowledge" about a certain item.

(51) Regression patterns are a feature of the explanatory behaviour of between 3 - 20% of Ss, depending on the type of item. More girls registered regression than boys.

(52) Remote stimulus material promotes more regression than does familiar or malfunctional material, lag patterns seem to be the most dominant pattern irrespective of the type of stimulus material. However, the nature of the "drop" is related to the nature of the stimulus material. 2 - 3 - 3 and 3 - 4 - 4 being a feature of familiar, 2 - 3 - 3 for malfunctional and 5 - 6 - 6 and 4 - 6 - 6 for remote causal contexts.

(53) Several factors may be responsible for regression, the presentation of the stimulus material, the question wording, have been suggested by other workers. However a likely factor may also be the nature of the stimulus material. Remote material clearly is related, in this investigation to regression phenomena. However, the reaction from some Ss interviewed, suggest that motivational and mnenomic factors might be playing a part too.

(54) The findings on regression clearly run contrary to Piaget's position on developmental processes. However, the findings here are supported by the work of other researchers, also refuting the Piagetian position even if comparability between the various studies is not strictly the same. Clearly, the nature of regression phenomena and the factors affecting them is an area for likely research.

(55) Erratic patterning is a marked, although variable feature of childrens causal appreciation as investigated here. Symmetrical apical and symmetrical depression effects are both common.

(56) All three types of stimulus material promotes a large variety of pattern types; with familiar material promoting 4 - 3 - 4 and 3 - 4 - 3, 3 - 2 - 3 and 2 - 3 - 2. However, remote material elicits enormous diversity but the 4 - 3 - 4 and 3 - 4 - 3 appear to be the most common. Malfunctional material promotes similar types to familiar but there is a greater frequency of higher response categories.

(57) The extent of erratic patterning (or "vacillations" as they are described by other workers) found in this investigation, indicates the variety of ways children fluctuate in their level of causal appreciation. This finding suggests cautious interpretation should be exercised in assigning children too rigidly to a particular developmental status.

(58) Explanations for the diversity, nature and occurrence of erratic patterning probably lies in a nexus of several influences. Remote material clearly promotes diversity. However influences such as methodological, mnenomic, motivational and maturational factors cannot be ruled out in attempting to clarify the nature and occurrence of these fluctuations. Like regression, further research into fluctuations in children's explanation and the factors responsible would be worthwhile especially from an educational point of view.

(59) The effects of practice vary from item to item, and it is difficult to assess precisely, however an overall view indicates that progressive change and any accompanying upward movement recorded for the erratic patterns in the Experimental groups, was also shown by controls Ss. This indicates the limited influence practice had in this study.

(60) The use of controls in this investigation, also act as a valuable comparative and monitoring device for the experimental group. Comparison between the results of a two test control and three test experimental design on the same sample, enables the researcher to gauge the <u>extent</u> and <u>nature</u> of developmental change of individual Ss, as well as groups of individuals.

CHAPTER 12

IMPLICATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

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Below are some of the more important implications and suggestions for further research that have arisen as a result of the present study.

(a) From both the first year study and the longitudinal follow up it has been found that malfunctional causal contexts promote higher categories of explanation. Further research into the nature of negative or reverse situations (and not necessarily causal ones) could throw more light on the content-process issue in Cognitive Development. This in turn, might have valuable implications for matching more appropriately, the content and approach of curriculum subjects to the child's ability.

(b) Further longitudinal and cross sectional studies entailing the use of the PCTB or similar battery are necessary to establish first, its further validity and secondly, to explore its use with other age ranges, of their appreciation and analysis of causal situations. Such studies if extended to history, social studies, geography, science etc. might show how children of different ages develop causal analytical ability, an important ingredient in the understanding of these subjects.

(c) Progressive patterns of explanatory behaviour as revealed by longitudinal studies are important from an educational point of view; for they indicate how children improve their performance over time. Further research involving different curriculum subjects e.g. history, geography and following up different cohorts, tested more frequently than was done here; would firstly explore, and later hopefully establish, patterns of children's mental development in curriculum subjects. This would have implications for monitoring children's progress and providing a more valid basis for their assessment.

(d) The establishment of "cognitive development profiles" either for individuals or groups of individuals, and using qualitative and quantitative data collected longitudinally, could provide a more valid picture of school children's patterns of performance. The profile, could include a combined visual representation of childrens performance as measured by IQ and qualitative tests based on Piagetian type tasks.

(e) Regression and erratic patterns of childrens development were fairly marked feature in this longitudinal study. Further research is required to investigate the nature of this pattern, and particularly the possible causes. This research, could hopefully have implications in explaining how and why children regress in certain school subjects e.g. mathematics etc.. A study of mnemonic and motivational variables might be valuable starting points for such research.

(f) The lack of adequate statistical treatments for analysing the qualitative data obtained in a longitudinal study is a serious handicap in such a study. While multidimensional methods are suitable for dichotomous data, more complex categorisations are not possible to treat. A possible area of research for this problem would be to explore the possibilities of probability, in the form of the Markov chain treatment.

(g) One of the main methodological problems which this study attempted to examine was the analysis and assessment of children's explanations. Research is required to provide more realistic guidelines first, for establishing what common criteria may be part of any child's explanation in certain situations and approximately at certain ages. Secondly, special features in childrens explanation related to subject disciplines.

Having begun to tease out these aspects, then perhaps categorising and scoring children's explanation might lead to a more realistic understanding of the concept of psychological distance. Research both in the analysis and assessment of children's explanation, could hopefully provide teachers and curriculum developers with more valid tools for the planning, sequencing and assessment of children's learning.

(h) Useful research having favourable educational implications would be to examine either in causal or non causal contexts, the relative value of employing purely verbal, as opposed to a mixture of demonstrational psychomotor and verbal form of presentation and measurement.

Many educators strongly advocate the use of practical approaches to learning and teaching as a means of more effective study. However studies examining to what extent the understanding of different branches of a subject e.g. Science, Geography is enhanced or otherwise, by using different modes of presentation and assessment, would be useful not only for preparing new teaching materials, but re-examining the old.

(i) Further research into the factors affecting causal thinking would be fruitful, especially the role of teaching in the context of a longitudinal study. Carefully controlled experiments which analyse the nature of what is taught, when and how; linked to consistent and careful monitoring of childrens developmental patterns, could lead to the development of valuable learning and teaching strategies. Such strategies, would not only be a important source of information, throwing light on several crucial and problematical areas in cognitive psychology e.g. stage theory, equilibration, transitivity etc., but would also provide teachers with a better means to assess learning conditions for their children.

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APPENDIX A - CAUSAL INSTRUMENTATION

CONTENTS

APPENDIX A_1 Physical Causality Test Battery (PCTB)

1 What makes a motor car go?

1a Can you tell me more? What makes the .... do that?

2 Are there other ways which you can think about that could make a car go?

2a Can you think of any other ways?

3 Which of the ways you have said is most likely to make a motor car go?

3a What makes you say that one?

4 Where did you find this out about the workings of a motor car?

5 What makes a cloud move?

5a Can you tell me more? What makes the ...... move the cloud?

6 Are there other ways which you can think about that could make a cloud move?

6a Can you think of other ways?

7 Which of the ways you have said is the most likely one to make a cloud move?

7a What makes you say that one?

8 Where did you find this out about the movements of clouds?

9 What makes a clock stop?

9a Can you tell me more? What does ...... do to stop the clock?

10 Are there other ways which you can think of that could make a clock stop?

10a Can you think of other ways?

11 Which of the ways you have said is most likely to make a clock stop?

11a What makes you say that one?

12 Where did you find this out about the stopping of clocks?

13 What makes boats stay on top of water?

13a Can you tell me more? What does ...... do to make the boat stay on top of the water?

14 Are there other ways that enable boats to stay on top of the water?

14a Can you think of other ways?

15 Which of the ways you have said is most likely to enable a boat to stay on the top of the water?

15a What makes you say that one?

16 Where did you find this out about boats staying on the top of water?

17 What makes lightning?

17a Can you tell me more? What does ...... do to make lightning?

18 Are there other ways which you could think of that makes lightning?

18a Can you think of other ways?

19 Which of the ways you have said is most likely to produce lightning?

19a What makes you say that one?

20 Where did you find this out about lightning?

21 What makes glass break?

21a Can you tell me more? What does ...... do to make glass break

22 Are there other ways that you can think about that could make glass break?

22a Can you think of other ways?

23 Which of the ways you have said is most likely to make glass break?

23a What makes you say that one?

24 Where did you find this out about the ways glass breaks?

25 What makes a bird fly?

25a Can you tell me more? What does ...... do to make the bird fly?

26 Are there other ways you can think about that could make a bird fly?

26a Can you think of other ways?

27 Which of the ways you have said is most likely to make a bird fly?

27a What makes you say that one?

28 Where did you find this out about the ways a bird flies?

29 What makes a space ship move?

29a Can you tell me more? What does ...... do to make a space ship move?

30 Are there other ways that you can think about that could make a space ship move?

30a Can you think of other ways?

31 Which of the ways you have said is most likely to make a space ship move?

31a What makes you say that one?

32 Where did you find this out about the ways that space ships move?

33 What makes a train crash?

33a Can you tell me more? What makes ...... do to make a train crash?

34 Are there other ways that you can think that could make a train crash?

34a Can you think of other ways?

35 Which of the ways you said is most likely to make a train crash?

35a What makes you say that one?

36 Where did you find this out about the ways trains crash?

37 What makes a television set give a picture?

37a Can you tell me more? What makes ...... do to give a picture?

38 Are there other ways you can think about that could make a television give a picture?

38a Can you think of other ways?

39 Which of the ways you have said is most likely to make a television give a picture?

39a What makes you say that one?

40 Where did you find this out about the ways by which a television can give a picture?

41 What makes us dream?

41a Can you tell me more? What does ...... do to make us dream?

42 Are there other ways you can think about that could make us dream?

42a Can you think of other ways?

43 Which of the ways you have said is most likely to make us dream?

43a What makes you say that one?

44 Where did you find this out about the ways that make you dream?

45 What makes people die?

45a Can you tell me more? What does ...... do to make people die?

46 Are there other ways you can think about that could make people die?

46a What makes you say that one?

47 Which of the ways you have said is most likely to make people die?

47a What makes you say that one?

48 Where did you find this out about the ways people die?

49 What makes a bicycle go?

49a Can you tell me more? What does ...... do to make the bicycle go?

50 Are there other ways you can think about that could make a bicycle go?

50a Can you think of other ways?

51 Which of the ways you have said is most likely to get a bicycle to go?

51a What makes you say that one?

52 Where did you find this out about the ways that make a bicycle go?

53 What makes the night?

53a Can you tell me more? What does ...... do to make night?

54 Are there other ways you can think about that could make the night?

54a Can you think of any more?

55 Which of the ways you have said is most likely to give us night?

55a What makes you say that one?

56 Where did you find this out about the ways that make night?

57 What makes a boat sink?

57a Can you tell me more? What does ...... do to make a boat sink?

58 Are there other ways you can think about that could make a boat sink?

58a Can you think of other ways?

59 Which of the ways you have said is most likely to get a boat to sink?

59a What makes you say that one?

60 Where did you find this out about the ways that make boats sink?

61 What makes a plant grow?

61a Can you tell me more? What does ...... do to make the plant grow?

62 Are there other ways that you could think about that could make a plant grow?

62a Can you think of any others?

63 Which of the ways you have said is most likely to make a plant grow?

63a What makes you say that one?

64 Where did you find out about the ways that make plants grow?

65 What makes the rain?

65a Can you tell me more? What does ...... do to make the rain?

66 Are there other ways that you could think about that could make rain?

66a Can you think of others?

67 Which of the ways you have said is most likely to make rain?

67a What makes you say that one?

68 Where did you find this out about the ways that rain is made?

69 What makes a balloon burst?

69a Can you tell me more? What does ...... do to make the balloon burst?

70 Are there other ways that you could think about that could make a balloon burst?

70a Can you think of other ways?

71 Which of the ways you have said is most likely to make a balloon burst?

71a What makes you say that one?

72 Where did you find this out about what makes a balloon burst?

APPENDIX A_2 Physical Causality Test Battery - Response and Scoring Guide for Initial Causal Components

FAMILIAR ITEMS

Car movement

A Category 1 Type Explanation

The driver turns the ignition key sending electricity from the battery to run the starting motor which gets the big engine going. Petrol starts feeding to the engine through the carburettor which is now a vapour, when it gets to cylinders. A spark plug ignites the vapour in the cylinder and then this pushes a crankshaft which is linked to a driveshaft. The driveshaft and axle are connected by ring gears which eventually turn the rear wheels of the car and it makes the car move forward.

A Category 2 Type Explanation

The driver turns the key which sends electricity from the battery, then the petrol goes through the carburettor and this gets the engine to go. The petrol gives power to the engine to turn the wheels.

A Category 3 Type Explanation

"The key is turned and gets the petrol to the engine"*

or "Petrol and the carburettor with the accelerator and petrol"*

A Category 4 Type Explanation

"Petrol and Engine"*

"Ignition Key" etc.

* Responses in inverted commas are actual examples of S's explanations

Boats Floating

A Category 1 Type Explanation

As a boat is hollow it weighs less than the water it displaces, so the buoyant force will hold it up making it float. If the boat was solid it would weigh more than the water displaced so the buoyant force would not be able to hold it up in the water.

A Category 2 Type Explanation

The boat weighs less than the water so the pressure (or force) will hold it making it float

or

The boat stays on the water because it is lighter.

A Category 3 Type Explanation

The boat is lighter on the water.

A Category 4 Type Explanation

"Lightness" "the wood", "the water", "not heavy".

Bird Flight

A Category 1 Type Explanation

As the bird spreads its wings they are curved like an aeroplane's wings. The top surface is convex and the lower concave. During flying the wings are raised above the bird's back and then pulled downwards. In this way the the curved surface of the wing compresses the air and the bird is carried forwards and upwards.

A Category 2 Type Explanation

The bird flaps its wing and this presses the air under the wings so that the bird flies.

A Category 3 Type Explanation

"By flapping its wings"

A Category 4 Type Explanation

"Wings" "Feathers" "Pressure of air"

Television Picture

A Category 1 Type Explanation

A TV camera takes films sending the pictures through the air by radio waves, which are recorded by the aerial, then the television set changes the electrical signals which represent the pictures and which have come in small bits. These go to an electron gun at the back of the picture tube. This gun "paints" the picture on the TV screen by shooting the electrons via the current at the screen. The shooting starts at the top of the screen from left to right, for the whole screen and this recreates all the lines of the picture very fast, and this is what makes the picture.

A Category 2 Type Explanation

The camera sends pictures by waves through the air, which the aerial picks up, and small bits of the picture are shot on the screen. This is what makes the television picture.

A Category 3 Type Explanation

"The aerial sends the picture"

"The television camera gives us the picture"

"The tube and television camera together"

A Category 4 Type Explanation

"Aerial" "Camera" "Tube" "TV Screen" etc.

Bicycle Mechanism

A Category 1 Type Explanation

By applying force in a forward direction on the pedals, which are attached to a large cog wheel and which has a chain running to a smaller cog attached to the rear wheel. The bike then moves along.

A Category 2 Type Explanation

The pedals turn the back wheel around as it has a chain wound around the two cogs. As you pedal it makes the bike move.

A Category 3 Type Explanation

"Pedals and Chain make it go"

"Pedals and the wheels together".

A Category 4 Type Explanation

"Pedals" "Chain" "Wheels"

Plant Growth

A Category 1 Type Explanation

A plant grows or increases in size at the ends of its roots and stems, the increase in size is due to the fact that protoplasm produces more and more molecules of cellulose which are deposited between the cell walls. The protoplasm produces this material from water and carbon dioxide with sunlight and chlorophyll.

A Category 2 Type Explanation

A plant grows by making its own food from water, and carbon dioxide and sunlight which makes it bigger.

A Category 3 Type Explanation

Water, sunlight and green leaves together etc.

A Category 4 Type Explanation

"Water" "Sunlight" "Soil and Water"

Remote Items

Cloud Movement

A Category 1 Type Explanation

The force of the wind carries and pushes the cloud which in turn makes the cloud move. The greater the force the faster the cloud will move.

A Category 2 Type Explanation

The wind is strong enough to push along the clouds so making them move.

A Category 3 Type Explanation

The wind is making it move.

A Category 4 Type Explanation

Wind, Pressure, Force.

Origin of Lightning

A Category 1 Type Explanation

The actual flash of lightning is due to a number of electrical discharges all following the same track at very short intervals of time. This makes the lightning strike. The discharge is started by a faint leader stroke often passing down a track in stages. The thunder that follows is the sound of the discharge.

A Category 2 Type Explanation

Lightning is made by electrical power in the sky which gives the light and then is followed by a thunder noise.

A Category 3 Type Explanation

"Electricity in the sky makes a light."

A Category 4 Type Explanation

"Electricity"

"Flashing"

"Power"

"Charged air"

Space Ship Movement

A Category 1 Type Explanation

They move by a thrust which is obtained from hot gases which are pushed out by burning a fuel. Space ships can travel where there is no air since they carry the oxygen needed for burning instead of taking it from the air. The thrust is what makes the space ship move.

A Category 2 Type Explanation

Fuels are burnt by the engines and this is what makes the space ship move "Fuels propel it along".

A Category 3 Type Explanation

Fuel burning makes it

Fire coming out

Engine and fuel make it move

A Category 4 Type Explanation

Fuel, Engine, Fire

Origin of Night

A Category 1 Type Explanation

As the earth is circulating around the sun it is also spinning on its own axis like a top. It takes 24 hours to do this so that part of the earth faces the sun for part of 24 hours and is lit up while the other half is dark. It is this spinning in relation to the sun that gives us the night and also the day alternatively in 24 hours.

A Category 2 Type Explanation

Earth moves around the sun and takes 24 hours to do it. When one half moves away from the sunlight this gives the night to that part.

A Category 3 Type Explanation

"Earth moving around the sun"

A Category 4 Type Explanation

"Earth moving," "no sun."

Origin of Dreams

A Category 1 Type Explanation

Dreaming happens when you sleep and during this time the brain is active. Dreaming occurs at the early part of sleep and is a form of thinking. Rapid eye movements occur during dreaming.

A Category 2 Type Explanation

When you sleep the brain is active and you think about things which make you dream.

A Category 3 Type Explanation

"Sleeping and you think"

"Your brain working."

A Category 4 Type Explanation

"Sleep," "Brain."

Origin of Rain

A Category 1 Type Explanation

If the air is carrying all the moisture it can it go upwards and has less presure on it and so it expands. As it expands it cools, now cool air cannot hold so much water as hot air because the small particles or molecules move slowly and so they come together and form drops. The drops if they become large enough fall as rain.

A Category 2 Type Explanation

Moisture in the clouds becomes cool as they rise and this condenses and water drops are produced which give rain.

A Category 3 Type Explanation

"Rain clouds blown high up"

"Water collects in clouds."

A Category 4 Type Explanation

Rain clouds, Water from sea

Water Vapour.

Malfunctional Items

Clock Stopping

A Category 1 Type Explanation

When the coil of the main spring is completely unwound there is no connection with the ratchet wheel which in turn does not connect via a shaft to the minute hand. The wheel interlocks with the hour hand and is eventually affected which means the clock comes to a stop.

A Category 2 Type Explanation

When the spring inside unwinds and this disconnects with some ratchet wheels making the clock stop.

A Category 3 Type Explanation

"No spring working"

"Falls and breaks spring".

A Category 4 Type Explanation

"Spring broken"

"Falls down."

Train Crashing

A Category 1 Type Explanation

As a train is travelling along,it may come across a broken line or some object on the line,which causes the train to come off the rails, due to the great force exerted by the engine and its impact against the object or broken line.

A Category 2 Type Explanation

An object like a stone on the railway line causes the train to come off the line because of the force of hitting it.

A Category 3 Type Explanation

"Stone on the line" "Wheel coming off line"

"Broken line making it come off".

A Category 4 Type Explanation

"Broken line" "Wheels skidding".

People Dying

A Category 1 Type Explanation

People can die naturally by their heart failing, which does not pump the blood around the body, so that the cells and issues are deprived of food and oxygen; also you can't get rid of waste and this causes death eventually.

A Category 2 Type Explanation

Heart fails and no blood is pumped around the body, so you get no oxygen and this causes us to die.

A Category 3 Type Explanation

"Heart stops beating and you die."

A Category 4 Type Explanation

"Heart stops."

Boat Sinking

A Category 1 Type Explanation

As a boat floats it weighs less than the water, but if a hole is made into the side of a boat water rushes in. This water will fill the boat up, making it heavier than the water displaced, so the buoyant force would not be able to hold it up in the water.

A Category 2 Type Explanation

As water comes in through a hole it makes the boat heavier and this makes it sink.

A Category 3 Type Explanation

"Water coming in the boat"

"Water makes it heavy"

"Hole in the side and water coming in."

A Category 4 Type Explanation

"Heavy," "Water," "Hole in side."

Balloon Bursting

A Category 1 Type Explanation

As air is blown into the balloon it fills the space and presses against the rubber walls which cause them to stretch. The more air that goes in, the greater will be the pressure on the walls of the balloon, until they cannot take any more and they break.

A Category 2 Type Explanation

Air pressure becomes so great, it makes the wall of the balloon break and you get a burst balloon.

A Category 3 Type Explanation

"Putting Air in the balloon", "Too much air makes it".

A Category 4 Type Explanation

"Air pressure", "Air in the balloon", "Pressure".

Physical Causality Test Battery - Category Guide - Initial Causal Components

Probe 1	Probe 2	Collapsed Category	Probe 1	Probe 2	Collapsed Category
1	1	1	5	1	1
1	2	1	5	2	2
1	3	1	5	3	3
1	4	1	5	4	4
1	5	1	5	5	5
1	6	1	5	6	5
2	1	1	6	1	1
2	2	2	6	2	1
2	3	2	6	3	3
2	4	2	6	4	4
2	5	2	6	5	5
2	6	2	6	6	6
3	1	1			
3	2	2			
3	3	3			
3	4	3			
3	5	3			
3	6	3			
4	1	1			
4	2	2			
4	3	3			
4	4	4			
4	5	4			
4	6	4			

APPENDIX A_3

Causal Demonstration - Water Level Test

Apparatus

1. Plastic beaker measuring 6 cms diameter x 12.5 cms high.
2. Plasticine - rolled out in a flat piece.
3. Ball bearing weighing approx. 50 grams.
4. Green coloured water.
5. Spoon.
6. Black marking pencil.

PART I Preliminary Test

---

1. There are no tricks with this test and there are no right or wrong answers, all I want you to do is to listen carefully to what I am saying and to answer me when I ask you a question.
2. Think very hard before you answer.
3. If you do not want to answer a certain question just tell me: or if you do not know the answer say "I don't know".
4. This is a plastic beaker and in it I have put some coloured water, can you point with your finger where the top of the green liquid comes to?

   I will now mark the position with this pen.
5. I would like you to look at these objects which I have here, this is a piece of clay and this is a ball bearing. Now put your both hands out with the palms of the hands quite flat. I shall put the clay on this palm and the ball bearing on this one.
6. Can you tell me anything about the two objects?
7. Now put the two objects down on the table.

PART 2 Prediction Test

8. I am now going to put the ball bearing into the coloured water, but before I do so, try and guess what will happen to the top of the water I marked earlier?

9. What makes you say that?

PART 3 Action Test

10. Now watch me carefully as I put the ball bearing into the coloured water, has anything happened?

11. Can you remember what you said would happen, were you correct?

12. Let me mark the new place where the coloured water is with this black pen.

13. Is it higher than the first mark I made?

14. Now what makes the water go up to that mark?

PART 4 Prediction Test

15. I will now put the clay into the coloured water, but before I do try and guess what will happen to the top of the coloured water?

16. What makes you say that?

PART 5 Action Test

17. Now watch me as I put the clay into the beaker containing the coloured water. Has anything happened?

18. Can you remember what you said would happen, were you correct?

19. Let me mark the place where the coloured water comes to. Now, is this last mark higher than the 1st mark I made there, and is it higher than the second mark I made?

20. Which object has made the water go highest then?

21. What has made the clay do that?

APPENDIX A_4 - Causal Reasoning Tests

APPENDIX A_4 Causal Reasoning Tests

Test 1 - Detection of Cause and Effect

Instruction: Listen to this sentence carefully and then try to answer the questions.

Statement: The man fell from the ladder as his foot missed the top step.

Questions: (What caused the man to fall from the ladder?
(
(What was the effect when the man's foot missed the top step?

Test 2 - Causal Ground

Apparatus: Drawing of a broad bean seedling on a card (See Fig. No. 16 opposite)

Instruction: I would like you to look at this drawing of a young broad bean seed. This is its root and here coming out of the top is its stem and leaves. Now try and answer this question about the picture.

Statement: Can you tell me the things that happened to make what you see in the picture?

Can you tell me anything else?

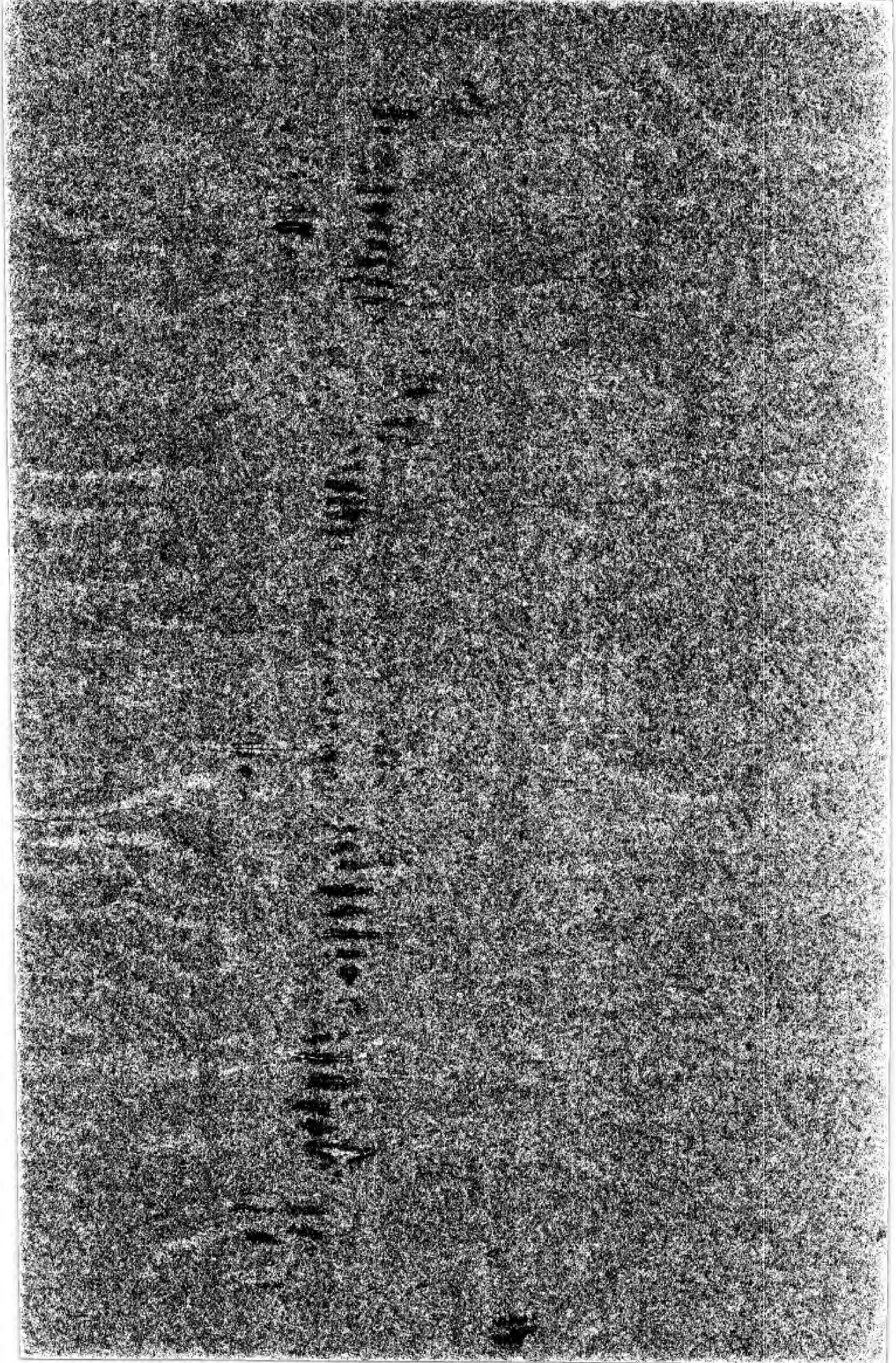
Question: Which thing/s came first to start it all off?

Test 3 - Invariant sequence

Instruction: Listen to this sentence carefully and then try to answer the questions.

Statement: As the sun goes down in the sky in the evening, the sky and everything gets darker.

Questions: (Is this what usually happens?
(
(What makes you say so?



Test 4 - Detection of a chance event

Apparatus: Wooden box 15.5 x 10 x 8 cms, 22 medium size marbles.

Instruction: Look at these coloured marbles which I have in this box, now close your eyes and take one of the marbles from the box, then open your eyes and try to answer this question:-

Question: What made you choose that one?

Test 5 - Detection of an incongruity

Instruction: Listen to this sentence which I am going to read out to you and then try to answer the question I put to you.

Statement: People like to eat chocolate because it gives them tummy ache.

Question: Is this what makes people eat chocolate? What makes you say so?

Test 6 - Causality in terms of action

Instruction: Listen to this sentence which I am going to read out to you and then try and answer the questions I put to you.

Statement: As the glass bottle fell to the floor it broke.

Questions: (Can you tell me what made the bottle break?
(
(Can you tell me more?

Test 7 - Contingency and necessity

Apparatus: Drawing of 2 cars approaching one another on a road (see Fig. No. 17 opposite).

Instruction: Look at the picture which is a map looking down on two cars approaching one another on a narrow country road.
The cars are going at 100 m.p.h. and there
is no time for each of the drivers to put their brakes on.
Now answer the following questions:

Questions: (What do you think will happen?
(
(Could you think of anything else happening to the two cars?
(
(What is the most likely thing to happen?

Test 8 - Retroactive Causality

Instruction: Listen to this sentence very carefully and then try to answer the questions I put to you about it.

Statement: The more the girl laughed the louder her voice became, the louder the girl's voice became the more the girl laughed.

Questions: What makes the girl laugh?
What makes the girl's voice get louder?
Which makes the other happen, the laughing or the loudness of the voice?
What makes you say so?

Test 9 - Detection of cause and effect

Apparatus: Plunger capacity 5cc^{3}s, a 250 ccs^3 beaker half filled with water.

Instruction: Here is a plunger or syringe, have a good look at it and watch me carefully (Water is pushed out of the plunger into beaker). Now try to answer these questions:

Questions: Now, what happened?
Can you tell me what caused it to happen?
What effect did my hand have in pressing the handle?

Test 10 - Causal Ground Appreciation

Instruction: Listen carefully to this sentence and then try to answer the questions I put to you about it.

Statement: On Monday the boy did not go to school as he had a cold, but by Wednesday morning of the same week he was well enough to go to school.

Questions: What things do you think this boy did between Monday and Wednesday, so that he could be well by Wednesday to go to school?
Which thing do you think he did at first in order that he could get well?

Test 11 - Invariant Sequence

Apparatus: Electric circuit, buzzer, battery and switch.

Instruction: Here is a buzzer, circuit and battery and press button. Have a good look at it and then press the button. Now answer the questions I put to you.

Questions:
(Did you expect this to happen?
(What makes you say that?
(Is the buzzing the usual thing to happen?
(What makes you say that?

Test 12 - Detection of a Chance event

Instruction: Listen to this sentence carefully as I read it to you and then try to answer the questions I put to you about it.

Statement: The T.V. picture became blurred as we were having our supper.

Questions:
(Was it because we were having our supper that the T.V. picture became blurred?
(What makes you say that?

Test 13 - Detection of an incongruity

Apparatus: Drawing of two different sized isosceles triangles (see Fig. No. 18 see opposite).

Instruction: Here I have two triangles have a look at them (E shows card with triangles) as you can see they are like other triangles you have seen before. Now listen to what I have to say and then answer any questions I ask you.

Statement: As you can see the two triangles are the same size as well as being of the same shape.

Questions:
(Do you agree with what I have said?
(What makes you say that?

Test 14 - Causality in terms of Action

Instruction: Listen to this sentence carefully as I read it to you and then try to answer the questions I put to you.

Statement: The sun was so hot that it burnt the man's skin as he was sunbathing in the garden of his house.

Questions: (Can you tell me what made the sun burn the man's skin?
(Can you tell me more?

Test 15 - Contingency and Necessity

Instruction: Listen carefully to this sentence as I read it out to you, and then try to answer the questions I put to you.

Statement: A boy was sick and told his teacher he could not play games with the rest of the class.

Questions: (Do you think this boy could play games even if he was sick?
(What makes you say so?

Test 16 - Retroactive causality

Apparatus: Drawing of the rain cycle (see Fig. No. 19 see opposite).

Instruction: Look carefully at this picture, here is the sun shining down on a lake and from the lake water vapour comes up (or damp air). This gives us those white clouds which the wind blows and by the time they reach the land the rain clouds are made which then give the rain. This then falls on the land and as you see it flows back to the lake.

Statement: As the sun shines, the more likely the water from the lake will give off damp air (or vapour), to give the clouds, which give the rain and then the lake.

The more water there is in the lake, the more likely the lake will give damp air when the sun shines, which will then give us more clouds and therefore more rain.

Questions: (What makes the whole thing happen, the sun shining on the lake or the water in the lake? or anything else? What makes it all start?

(What makes you say so?

Test 17 - Detection of Cause and Effect

Instruction: Listen carefully to this sentence as I read it out to you and then try and answer the questions I put to you.

Statement: Mary's mother put too much salt in the soup and so made the soup taste very salty.

Questions: (What caused the soup to taste very salty?

(What was the effect of Mary's mother putting the salt in the soup?

Test 18 - Causal Ground

Instruction: Listen carefully to the following question I am going to ask you and then think before you answer it.

Questions: (What do you want to be when you grow up?

(Can you remember what was the first thing that made you want to become ....

(If you want to become ....

(Tell me the things you must do between now and the time you become ....

(What should you do first of all?

Test 19 - Invariant sequence

Instruction: Listen carefully to the following sentence and then try to answer the question I put to you on it.

Statement: After you turn a gas fire off in a room it begins to get colder until the room gets even colder after a time.

Questions: (Is this what usually happens?

(What makes you say so?

Test 20 - Detection of a chance event

Instruction: Listen carefully to the following sentence and then try to answer the question I put to you on it.

Statement: As the sun appeared in the sky, smoke came out of the cottage chimney.

Questions: (Did the sun appearing in the sky make the smoke come out of the cottage chimney?
(What makes you say that?

Test 21 - Detection of an Incongruity

Apparatus: A small sealed specimen tube, filled almost to the top with oil and water.

Instruction: Look what I have here, this is a container which has oil and water. Listen carefully to what I am going to say, and then try to answer the questions I put to you on it.

Statement: The oil and water in this container do not mix because they are the same substances.

Questions: (Do you agree with what I have said about these substances?
(What makes you say that?

Test 22 - Causality in terms of Action

Instruction: Listen to this sentence as I read it out to you and then try and answer the questions I put to you on it.

Statement: The girl told her friend that if she wished very hard she would get whatever she wanted.

Questions: (Can you tell me, does wishing get the girl what she wants?
(What makes you say that?

Test 23 - Contingency and necessity

Apparatus: Pendulum arrangement and retort stand.

Instruction: Look carefully at these things which I have in front of you, here is a stand and attached to it I have a ball and string. Now listen to the question I want to ask you

Statement: If I let this ball go fron this position what do you think is bound to happen (E moves ball outwards).

Questions: (Can you think of anything else that might happen instead?
(What makes you say that?

Test 24 - Retroactive Causality

Instruction: Listen carefully to this sentence which I am going to read out to you and then try and answer the questions I put to you on it.

Statement: The more the man rushed to mend his car the more excited he became, the more excited he became the more he rushed to mend his car.

Questions: (What makes the man begin mending his car?
(What makes the man more excited?
(What makes the other thing happen, mending the car or becoming more excited?
(What makes you say that?

APPENDIX A_5 ELECTRIC LIGHT PROBLEM

Apparatus: Circuit, 2 volt battery, two 1.5 watt lamp bulbs, lamp holder (one functional, one non-functional) press switch, crocodile clips and connection wires.

Part 1: Instructional Phase

1. This is a light bulb on a stand, this is a switch and a battery here are some wires with crocodile clips.

Now I want to see if you can use all these in such a way that you could get the light to go on.

(The S is allowed to spend no more than 3 minutes on this part of the test, in cases of poor connecting ability the E completes the task.)

Part 2: Explanatory Phase

2. Now that you have had the light to go on, can you tell me what made it go on?

2a. Come on try and guess hard.

3. Can you think of anything else here you have used that gets the light to go on.

4. Which of the things you have said is most likely to have made the light go on or do you think the *......... are all making the light go on?

4a. What makes you say so?

(If response is made to the or part continue with question 5)

5. Of them all which is the most important of the light to go

5a. What makes you say that?

Part 3: Confirmatory Phase

6. See if you could show me that it is the .... that/or .... really makes the light go on.

* Whatever the S gives as answers to 2a or 3

Part 4: Unrelated Activity

7. I am going to ask you to write down all the things you used to make the light go on.

(E disconnects whole circuit and replaces live bulb with a non-functional one while the S is writing out the list of apparatus on a page facing away from E's table)

Part 5: Malfunctional Phase

8. Now I wonder if you can get the light to go on, as you see I have dismantled all the connections.

(S proceeds to re-connect apparatus)

9. What makes the light not come on now do you think?

10. Can you think of other ways?

APPENDIX A_6 Bicycle Drawing Test

Apparatus: Pencils and sheets of A4 drawing paper

INSTRUCTIONS TO THE CLASS TEACHER

Introductory Remarks

This task aims to investigate childrens' ability to understand and communicate their appreciation of physical causality through drawing - For this purpose; one item is taken from the Physical Causality test namely the bicycle mechanism. For this particular task the essential parts, i.e. 2 wheels, 2 cogs, chain and pedal need to be drawn showing the correct spatial relationship between them.
By having information of this type, with information from other verbal and non-verbal causal tests it is hoped to have a fuller picture of the child's appreciation of causal phenomena.

(a) You could introduce the session to the class along the following lines:-

"Now you all know what a bicycle looks like and many of you actually have one. What I want you to do is to see if you can draw a bicycle to show me if you know how it works.

First of all try hard to remember about the different parts that make up a bicycle and then draw one.

Try to make your drawings big enough for me to see the various parts of the bicycle."

(b) Each child should write his or her name on the top of the drawing sheet.

(c) Drawings should be in pencil and should not be less than 10 cms overall.

(d) Children do not need to label the parts of the bicycle.

(e) There is no time limit laid down for the task, this is left to the teacher.

(f) No help should be given to the children in the actual drawing of the bicycle.

(g) Children who may need to repeat their drawing should specifically request this themselves and should only be allowed two repeats. Each drawing should be numbered in the order drawn.

(h) Children are allowed aids (e.g. compasses, rulers, circular objects for the wheels etc.) for drawing the bicycle if they request them.

(i) Children should be encouraged not to copy from each other.

(j) Any charts, books, models, etc. that are even remotely connected with bicycles and other wheeled objects should be put out of sight during the drawing session.

(k) Children are permitted to draw a certain type of bike they may know, e.g. racer, upright chopper etc.

Thank you for your cooperation

APPENDIX A_7 Causal Creativity Test

APPENDIX A_7 Causal Creativity Test (after Torrance)

Materials *Drawing of a child looking into a pool of water?

one for each child

Answer sheets with instructions

Pencils

Information and Instructions to the Class Teacher

This test aims to investigate childrens' creative ability with regard to a causal situation. By having information from this dimension it is hoped that a further picture of the ways children appreciate causality may be obtained. It is also hoped to determine what relationship if any creative thinking in causality has to other facets of the process.

(a) You might introduce the session to your class along the following lines:-

"I would like you to look at the picture in front of you very carefully and then to listen what I want you to do next."

"Now let me read what it says on the paper with the space for your name and all these lines on it."

(Teacher proceeds to read the instructions)

"Now put your name on the paper where it says name."

"Let me read again what it says".

(b) Apart from explaining what is expected of the children procedurally, no help should be given to them.

(c) There is no time limit laid down for the test, this is left to the teacher's discretion.

(d) Please check that each child has filled his or her name at the top of the page and any subsequent ones.

Thank you for your cooperation

* See Figure No. 21 opposite

APPENDIX A_7 - CAUSAL CREATIVITY TEST - ANSWER SHEET WITH INSTRUCTIONS

Name: ....

In the spaces below write down as many guesses as you can of what you think is making the things you see in the picture happen. You may put things down that might have happened just before or that happened a long time ago, that made these things happen. Make as many gueses as you can. A guess can take more than one line if you lik.

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________

7. ____________________

8. ____________________

9. ____________________

10. ____________________

11. ____________________

12. ____________________

13. ____________________

14. ____________________

15. ____________________

.
.
.
.

30. ____________________

APPENDIX A_8 — Use of Causal Connectives Test

Introduction to Test

(Each S was asked by the E the following questions)

1. I would like you to complete some sentences and also to make some up, using words I will give you.

2. Try hard to answer as best as you can. If you know just complete the sentence, or tell me the sentence you make up. If you don't know just say so.

(Before each set of completion items the E says
"Now see if you can complete the following sentences"

Before each set of construction items the E says
"Now try to make up a sentence using the word because etc.)

Completion items

1. The boy came off his bicycle because ....
2. The car ran out of petrol therefore ....
3. The boy threw a stone at the window but ....
4. I enjoy ice cream as it makes ....
5. The train was late due to ....
6. The apple fell from the tree as ....

Construction items

7. because

8. therefore

9. but

10. as it makes

11. due to

12. as

Completion items

13. Teachers know what is good for their pupils because ....

14. The central heating in Jane's house works well therefore ......

15. The boy sat his spelling test three times but ....

16. A joke is often nice to hear as it makes ....

17. The shopkeeper was worried due to ....

18. Batteries make a torch light up as ....

Construction items

19. because

20. therefore

21. but

22. as it makes

23. due to

24. as

Completion items

25. Boats float on water because ....

26. The lightning made the lights in our home fail, therefore .....

27. A rock rolled over the cliff but ....

28. Washing up liquid is added to water as it makes ....

29. Glass windows usually break due to ....

30. No person is allowed into the class today as ....

Construction items

31. because

32. therefore

33. but

34. as it makes

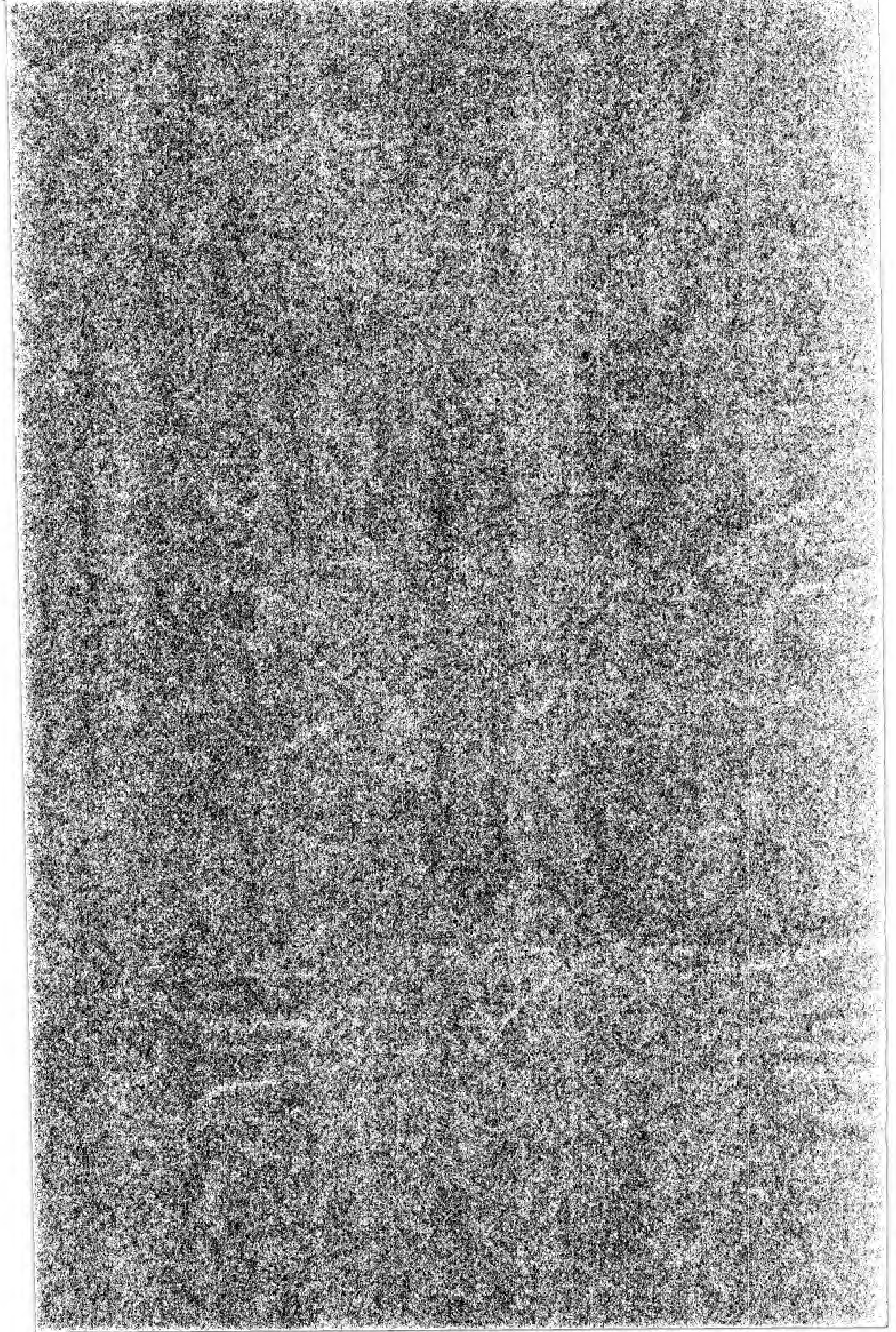
35. due to

36. as

APPENDIX B - NON-CAUSAL INSTRUMENTATION

Contents

APPENDIX B_1 <u>Relational Test</u>



APPENDIX B_1 **Relational Test**

Introduction

I am going to ask you some questions about certain things if you know the answer just tell me. if not just say "I don't know".

Statements and Questions

1. Show me your right hand and now show me your left hand.

   Name me something in this room which is to the right of you.

   Name me something in this room which is to the left of you.

   Now point to my right hand with your left hand.

   Point to something in this room which is on my left side.

2. David has sisters Cynthia, Mary and Anne, David also has brothers Peter and John.

   How many sisters has Peter?

   How many brothers has Mary?

   How many sisters has Anne?

3. Here is a card* with three shapes this is a triangle

   " " " semicircle

   " " " rectangle

   Is the semicircle above or below the triangle?
   " " " " " " " " rectangle?

(E reverses the card at this point)

. Is the semicircle above or below the triangle?
  " " " " " " " " rectangle?

4. Neil did not climb as high up the mountain as Susan but Neil climbs higher than Barry. Who in turn climbed higher than Elizabeth?

   Who climbs the highest of all the four children?

* See Figure No. 22 opposite

APPENDIX B_2 Judgemental/Verification Test

Apparatus: 1 rectangular block of iron measuring 2 x 3 x 4 cms

1 rectangle block of aluminium measuring 2 x 3 x 4 cms

Both blocks have an identical covering of white cardboard fixed on to all 6 sides of the blocks.

Spring Balance.

Procedure:

The two blocks of different metal which are made to look similar by covered white cardboard are placed in front of the S and the following questions asked:-

Questions

(a) Judgemental Phase

(1) Here are two pieces of metal; which do you think is the heavier?

(2) What makes you say that?

Questions (3) and (4) are asked if the S says "don't know" or if the S does not appear to understand the question. Otherwise E proceeds on to Questions 5 - 7 direct.

(3) Why don't you try and find out?

(Here the S is probed in order to pick up the shapes)

(4) What do you think now?

(b) Verification Phase

(during this phase a spring balance is made visible)

(5) How much heavier is one more than the other?

(6) How sure are you?

(7) How can you find out?

APPENDIX B_3

Scepticism Test

1.	Statement:	A boy stole some money from a school friend and was caught doing it by his teacher. The teacher told the class that the boy stole the money because he thought the boy was just doing it for a joke.
	Questions:	Do you think the teacher gave the real reason for the boy's stealing. What makes you say so?
2.	Statement:	Who is the cleverest member of your family?
	Questions:	Do you think there is anything *...... does not know? What makes you say so?
3.	Statement:	Last week I went ice skating on an ice rink and I did not fall down once. The only reason I did not fall was because I was wearing new skates.
	Questions:	Do you think I am right in saying that the skates were new, as being the only reason for me not falling down? What makes you say so?
4)	Statement:	A girl was going to take her piano examination and before she went into the examination room, her mother told her that all she needed to do to pass her piano examination, was to play softly.
	Questions:	Do you think the mother should have told her daughter anything more, so that she could pass her piano examination? What makes you say so?
5)	Statement:	John was told by his headmaster that the reason why John was not behaving himself in school, was that John was watching too many violent films on Television.
	Questions:	Now if you were John do you think that the headmaster was wrong in what he said to John about his behaviour? What makes you say that?

* Family members name goes here

APPENDIX B_{4S} — Conservation of Substance

Apparatus: 10 c^3 graduated glass cylinder
2 glass specimen tubes both having a capacity of 20 c^3,
5 small specimen tubes capacity $10c^3$
1 glass beaker 25 c^3 half full of coloured water
1 tray to support the above apparatus.

Procedure: This test was divided into the following parts :-
(a) Descriptive and Instructional
(b) Predictive
(c) Action
(d) Explanatory

Two specimen tubes, the $10c^3$ cylinder and the $250c^3$ beaker half filled with coloured water are placed on a tray in between the E and S sitting either side of a table.

(A) Descriptive and Instructional

1. Here I have two containers of the same size and here I have a beaker containing some coloured water.

2. Now watch me as I pour all the coloured water from here* into the two containers so that there will be as much coloured water in that one** as there will be in that one**.

3. Do you think that each container has as much coloured water? or do you think this one has less or more than this one?

(B) Predictive

4. Now suppose I take this container*** and pour all the coloured water into this sylinder here, will there be as much in there as in this container or will there be more or less in there?

4a. What makes you say that?

(C) Action

5. Now pour the coloured water from that container into the cylinder.

5a. Tell me, do you think there is as much coloured water in this container as there was in that one?

(D) Explanation

What makes you say that.

* Pours coloured water from glass beaker
** Pours separately into the 2 specimen tubes
*** Points to one of the 2 specimen tubes

NB. Same procedure adopted for the 5 tubes.

APPENDIX B_{4_W}

Conservation of Weight

Apparatus: Two equal amounts of plasticine

Board for rolling out plasticine

Spring Balance

Procedure: This test was divided into the following parts :-

(A) Descriptive and Instructional

(B) Predictive

(C) Action

(D) Explanatory

Two medium sized plasticine balls are placed in front of the S on a wooden board. Lying nearby is a Spring Balance.

(A) Descriptive and Instructional

1. Here I have two plasticine balls on this board and I want you to do certain things with them, and to ask you some questions about them.

2. Does this ball weigh the same as this one or does it weigh more or less than it?

(S is encouraged to take the two balls and place each on the palms of the hand).

If the response is negative or positive the S is encouraged to weigh both balls on the balance.

(B) Predictive

3. Suppose I take this ball and roll it out like a sausage, will the weight be as much as this one (pointing to ball) or will it be more or less than it?

(C) Action

4. Now roll this ball out, tell me if you think it has the same weight.

4a. Tell me, does this have the same weight as this one, or does it have more or less than it?

(D) Explanatory

5. What makes you say that?

APPENDIX B_{4_A}

Conservation of Area

Apparatus: 3 pieces of card on which are placed various areas of white paper. Card (i) has two rectangles.

Card (ii) has 8 squares plus one separate square

Card (iii) has five squares and three triangles plus a separate triangle

A pair of scissors.

Each of the three cards is placed in front of the S and the S is asked the questions below . Apart from minor modifications this test is similar to the one given by Lovell et al (1962).

A) Statements and Questions for Card (i)

1. Here are two rectangles which you have probably seen before.
2. Do you think they are the same size?
3. Match them if you wish.
4. Now I will cut this rectangle /E cuts the rectangle diagonally7.
5. Let me put the pieces such as to give this shape : /E makes a triangle from the two cut shapes - see Fig. No.23a7.
6. Do you think that this shape has the same size as that one?
7. What makes you say that?

B) Statements and Questions for Card (ii)

1. Now look at this shape with all these squares drawn on it.
2. Here I have a little square like one of those /E points to squares on the large shape see Figure No. 23b7.
3. By using this little square can you tell me how big all this is?
4. How did you get that?

C) Statements and Questions for Card (iii)

1. Now look at this shape with these squares and triangles drawn on it.
2. Here I have a little triangle like one of these here /E points to the shape see Figure No. 23c7
3. Using this little triangle can you tell me how big all this is? /E points to the Shape7.
4. How did you get that?

Figure No. 23 Conservation of Area (a)

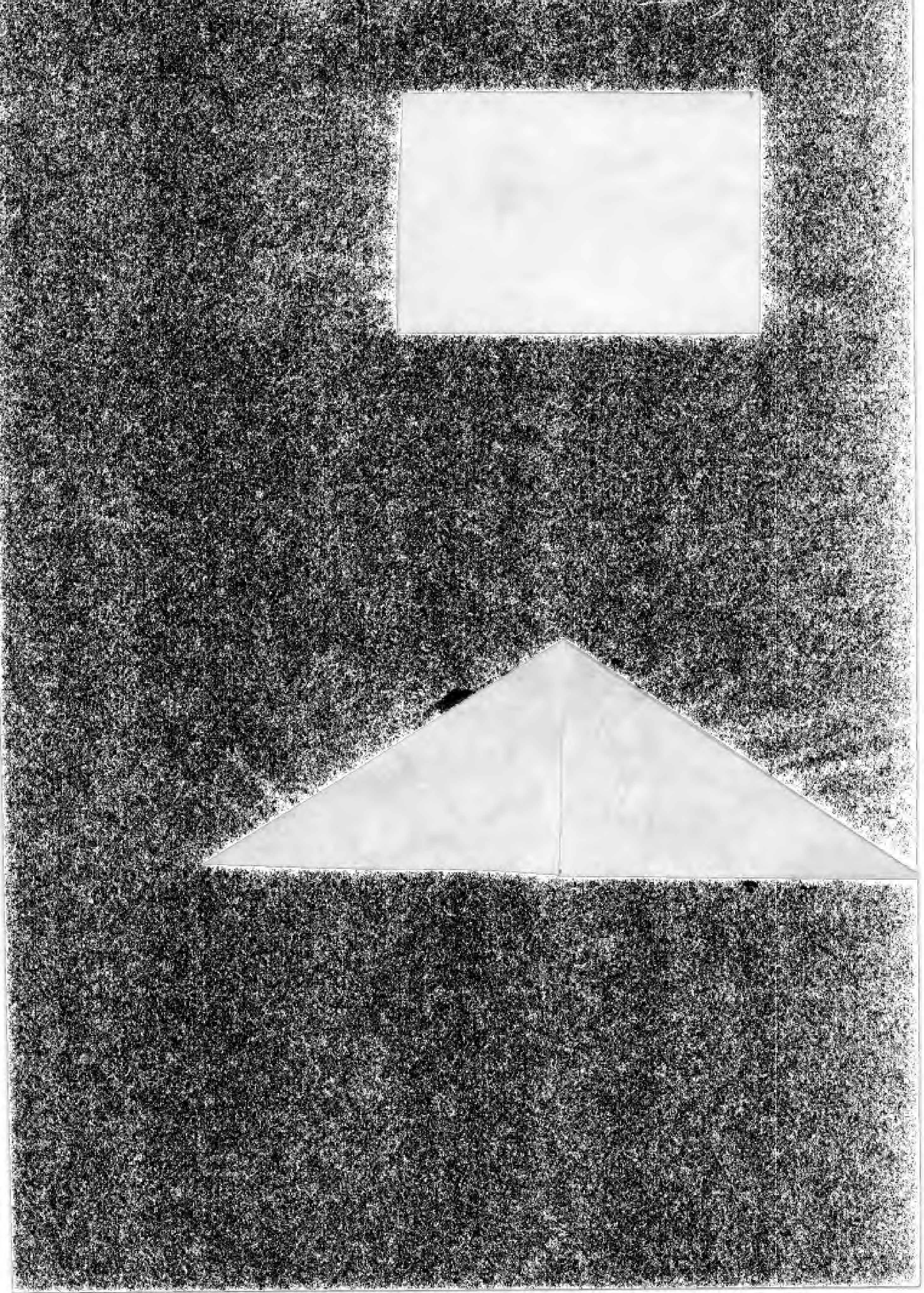


Figure No. 23 Conservation of Area (b)

Figure No.23 Conservation of Area (c)

APPENDIX B_{4V} Conservation of Volume

Apparatus: 24x1 c^3 wooden cubes

1 x 250 c^3 beaker

1000 c^3 beaker

Procedure:

This test was divided into 3 parts each part aimed to probe three aspects of volume.

(A) probing an appreciation of internal volume

(B) " " " " occupied volume

(C) " " " " displacement volume

The three tests are based mainly on the work of Lovell and Ogilvie (1961).

(A) Appreciation of internal Volume

Two differently arranged sets of 12 cubes are presented to the S then one of the sets is further re-arranged.

Statements & Questions

1. Here we have two blocks of bricks. (E points to block 2 x 2 x 3 and to block 2 x 3 x 2).

2. If we made two boxes one for each block of bricks so that there was just enough room in each box to hold the bricks; would there be as much room in one box as in the other, or would there be more, or less room in them?

3. What makes you say that?

(B) Appreciation of Occupied Volume

The 250 c^3 container and the 1000 c^3 container are shown to the S. The 250 c^3 is then filled to the brim with water.

Statements & Questions

1. This is a 250 c^3 container and smaller than this one. (E points to each respectively).

2. I will fill the smaller one with water I have here. (E fills 250 c^3 container).

3. Before filling the large one I shall put these bricks into it (E lowers bricks 2 x 3 x 2 into large container).

4. Now, if we fill this container to the top, do we get as much water into it before the bricks are put in, or would the bricks make a difference?

5. What makes you say that?

6. Suppose I put this set of bricks into the larger container (E points to a block measuring 1 x 2 x 6).

7. Can I get as much water into it as I could with the other lot of bricks, or would there be more or less?

8. What makes you say that?

(C) Appreciation of Complementary or Displacement Volume

In this part the 250 c^3 remains full of water and the 1000 c^3 container empty.

Statements & Questions

9. Lets pretend that the bigger container is as full of water, as the smaller one and that I will put this lot of bricks into it without splashing.

(E selects the 2 x 3 x 2 block of bricks and lowers it into the empty 1000 c^3 container).

10. Is it possible to put these bricks into the smaller container without spilling any water?
(E points to 2 x 3 x 2).

11. What makes you say that?

12. What happens if you place these bricks into the smaller container instead of these?
(E points to block of bricks 1 x 2 x 6 and then to blocked bricks 2 x 3 x 2).

13. Can you tell me how much water is spilled out, with the two different lots of bricks?

14. What makes you say that?

APPENDIX C Recording and Scoring Sheets

Contents

APPENDIX C_1

Proforma

Name of S.. No. of S................

Age........... Sex.............. Father Occupation........................

Nationality..................... Mother " ....

Ethnic Group.................... Religion................................

Family information e.g. siblings etc. ....

....

....

Previous Education

Schools attended...

....

....

....

Experiential Aspects

Interests of S in order of preference

....

....

....

....

....

....

Does the S have the following at home

TV ....

Radio ....

Car ....

Animals ....

....

....

....

....

Books on Science ....

....

....

....

Books on how things work ....

....

....

....

APPENDIX C_2

Physical Causality Test Battery - Recording Sheet

Testing ______

Name of Subject....................... Subject No.......... Date.............

Interview Comments

Question No.	Verbatim responses & transcription	Verbatim Category	Transcription Category
1	- -		
1a	- -		
2	- -		
2a	- -		
3	- -		
3a	- -		
4	- -		

APPENDIX C_3 Summary Sheet

	Motor	Boats	Bird	TV	Bike	Plants	Cloud	Lightning	Space Ship	Dream	Night	Rain	Clock	Glass	Train	People Die	Boat Sink	Balloon	N_1	N_2	N_3	N_4	NN	DK	-	+	F	S	M	B	C
3																															
2																															
1																															
3																															
2																															
1																															
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2																															
1																															

APPENDIX C_4 Causal Demonstration - Water Level Test

Name of Subject.................. Subject No.............. Date............

Interview Comments

Question No.	Verbatim responses and transcriptions	Verbatim Category	Final Transcribed Category

APPENDIX C_5 Causal Reasoning Tests

Name of Subject........................ Subject No.......... Date.............

Interview Comments

Question No.	Verbatim Response and Transcriptions	Verbatim Response Category	Final Transcribed Category

APPENDIX C_6 Causal Problem Solving Test - Electric Light

Name of Subject....................... Subject No........... Date............

Question No.	Verbatim Responses and Transcriptions	Verbatim Response Category	Final Transcribed Category

APPENDIX C_7 Use of Causal Connective Test

Name of Subject;;.......................... Subject No.......... Date..............

Category:	Completion	Construction	Interview Comments
+.	....	....	
-.	....	....	
DK	....	....	

Scores

Sentence No.	Verbatim Responses and Transcriptions	Verbatim Response Category	Transcribed Response Category

APPENDIX C_8 Specimen Recording Sheet for Relational/Judgemental/ Verification Test

Question No.	Verbatim Responses and Transcriptions	Verbatim Response Category	Transcribed Response Category

APPENDIX C_9 Specimen Recording Sheet for Conservation of Substance/Weight/Area/Volume

Name of Subject...................... Subject No.......... Date...............

Category

+ ....

\- ....

T ....

DK ....

Interview Comments

Question No.	Verbatim Responses and Transcriptions	Resp. Int.	Cat. Fin.

Appendix C 10

MASTER RESULTS SHEET FOR ALL TESTS PER SUBJECT

S. No. .... Name: .... Sex : ....

Age :.................. Class Teacher/s : ....

Parent Occupation : ....

PHYSICAL CAUSALITY TEST BATTERY

	TESTINGS 1 Stimulus Material				2 Stimulus Material				3 Stimulus Material			
Questions 1 + 1a combined	Familiar	Remote	Malfunction	Total	Familiar	Remote	Malfunction	Total	Familiar	Remote	Malfunction	Total
1 N_1												
2 N_2												
3 N_3												
4 N_4												
5 NN												
6 DK												
Question 2												
+												
–												
DK												
Question 2a												
+												
–												
DK												
Question 3												
+												
–												
DK												
Question 4												
+												
–												
DK												
Question 5												
F Familiar												
S Self												
M Media												
B Books												
S School												

Water Level Test

1(Q6) ____

2(Q12) ____

3(Q14) ____

4(Q18) ____

5(Q19) ____

6(Q20) ____

7(Q22) ____

Conservational Notions

Substance ____

Weight ____

Area ____

Volume ____

Relational Test ____

Language Test

Comp. ____

Const. ____

Judge/Verification Test ____

Scepticism Test ____

Drawing Test ____

Causal Reasoning

1	____	5	____
9	____	13	____
17	____	21	____
2	____	6	____
10	____	14	____
18	____	22	____
3	____	7	____
11	____	15	____
19	____	23	____
4	____	8	____
12	____	16	____
20	____	24	____

Electric light problem

Questions 2 & 2a ____

" 3 ____

" 5 & 5a ____

" 10 ____

" 11 ____

Creativity **Cause**

Fluency ____

Flexibility ____

Originality ____

Richmond Achievement Test

1	____	1	____
2	____	2	____
3	____	3	____
4	____	4	____
5	____	5	____
6	____	6	____
7	____	7	____
8	____	8	____
9	____	9	____
10	____	10	____
11	____	11	____

APPENDIX D Results - First Year Study

Contents

TABLE D_1 Showing KEY TO VARIABLES USED IN THE ANALYSIS

Variable No.	Designation
007	Physical Causality Test Battery Initial Causal Component - Familiar
008	Physical Causality Test Battery Initial Causal Component - Remote
009	Physical Causality Test Battery Initial Causal Component - Malfunctional
016	Physical Causality Test Battery Pluralistic Component - Familiar
017	Physical Causality Test Battery Pluralistic Component - Remote
018	Physical Causality Test Battery Pluralistic Component - Malfunctional
028	Physical Causality Test Battery Logico-Causal - Familiar
029	Physical Causality Test Battery Logico-Causal - Remote
030	Physical Causality Test Battery Logico-Causal - Malfunctional
053	Causal Demonstration - Water Level Test
056	Causal Connectives - Completion
057	" " - Construction
058	" Reasoning Tests
073	Richmond Test - Language Usage
074	" " - Mapping
075	" " - Graphs
076	" " - Reference
077	" " - Mathematical Concepts
078	" " - " Problem Solving
096	Relational Test
097	Verification Test
098	Scepticism Test
099	Bicycle Drawing Test
101	Causal Problem - Electric Light
102	" Creativity - Fluency
103	" " - Flexibility
104	" " - Originality

TABLE D_2 Showing MEANS AND STANDARD DEVIATIONS

Variable No.	Mean	Standard Deviation
007	10.000	3.557
008	6.519	3.806
009	11.519	3.824
016	2.686	2.101
017	1.437	1.531
018	5.323	2.637
028	0.764	1.290
029	0.450	0.923
030	1.705	2.277
053	3.578	1.636
056	9.196	3.435
057	4.431	3.290
058	9.539	4.591
073	40.274	27.507
074	43.951	22.906
075	46.656	25.675
076	45.186	25.195
077	42.451	25.434
078	45.078	29.714
096	12.754	4.962
097	1.400	1.000
098	2.019	1.340
099	4.362	2.684
101	15.470	6.306
102	3.480	2.400
103	2.245	2.000
104	2.529	2.111

APPENDIX D_3 - Correlation Matrix

TABLE D3$_1$ Showing Correlation Matrix for Variables 007 - 009, 016 - 018, and 028

	VAR007	VAR008	VAR009	VAR016	VAR017	VAR018	VAR028
VAR007	1.00000	.62372	.61640	.33867	.32498	.36838	-.31088
VAR008	.62372	1.00000	.49200	.27000	.22380	.34213	-.32350
VAR009	.61640	.49200	1.00000	.24547	.32302	.34541	-.22846
VAR016	.33867	.27000	.24547	1.00000	.67298	.42522	-.29135
VAR017	.32498	.22380	.32302	.67298	1.00000	.42742	-.04558
VAR018	.36838	.34213	.34541	.42522	.42742	1.00000	-.24388
VAR028	-.31088	-.32350	-.22846	-.29135	-.04558	-.24388	1.00000
VAR029	-.13731	-.16082	-.12475	-.24910	-.28839	-.26395	.20564
VAR030	-.23759	-.33780	-.24459	-.08259	-.00439	-.38049	.31436
VAR053	-.25418	-.30872	-.18667	-.16406	-.14626	-.20961	.20117
VAR056	.06430	.02835	.02501	.03169	.03101	.09941	.02902
VAR057	-.01047	-.08535	-.03850	.02272	-.02161	.09552	-.00751
VAR058	.11589	.05784	.03743	.07114	.06991	.18820	-.02511
VAR073	.14996	.21289	.20849	.07430	-.00199	-.01311	-.12454
VAR074	.15067	.21933	.23411	.17786	.02199	-.10267	-.22083
VAR075	.18321	.11976	.12212	.04113	.01550	-.15540	-.14072
VAR076	.04894	.20793	.12649	.11448	-.03094	-.19643	-.14545
VAR077	.18877	.29279	.30117	-.03801	-.10105	-.20089	-.20370
VAR078	.27999	.25550	.34960	.07193	-.02512	-.03381	-.20024
VAR096	-.04347	-.06804	-.00223	.00227	.02201	.06042	.08089
VAR097	-.05575	-.13906	-.13502	.14220	.18179	.00351	.04455
VAR098	-.16872	-.22993	-.17378	-.02049	-.02351	-.18331	.19437
VAR099	.11822	.05211	.03643	.11863	.10075	.07278	.06810
VAR101	-.09910	-.05721	-.18430	-.01097	-.06746	-.02861	.09164
VAR102	.11229	.18793	.08439	.09320	.07133	.05845	-.20461
VAR103	.01708	.14811	-.01500	.05525	.05124	-.02828	-.13125
VAR104	.17605	.19650	.11629	.07443	.11519	.05316	-.12457

TABLE $D3_2$ Showing Correlation Matrix for Variables 029, 030, 053, 056,057, 058, 073, 074.

	VAR029	VAR030	VAR053	VAR056	VAR057	VAR058	VAR073	VAR074
VAR007	-.13731	-.23759	-.25418	.06430	-.01047	.11589	.14996	.15067
VAR008	-.16082	-.33780	-.30872	.02835	-.08535	.05784	.21289	.21933
VAR009	-.12475	-.24459	-.18667	.02501	-.03850	.03743	.20849	.23411
VAR016	-.24910	-.08259	-.16406	.03169	.02272	.07114	.07430	.17786
VAR017	-.28839	-.00439	-.14626	.03101	-.02161	.06991	-.00199	.02199
VAR018	-.26395	-.38049	-.20961	.09941	.09552	.18820	-.01311	-.10267
VAR028	.20564	.31436	.20117	.02962	-.00751	-.02511	-.12454	-.22083
VAR029	1.00000	.25555	.13628	-.16681	-.03860	-.19227	-.08979	.07475
VAR030	.25555	1.00000	.11615	.05501	.16142	-.02970	-.33239	-.18314
VAR053	.13628	.11615	1.00000	.14745	.25152	.13350	.10298	-.22891
VAR056	-.16681	.05501	.14745	1.00000	.59253	.95356	-.09366	-.19860
VAR057	-.03860	.16142	.25152	.59253	1.00000	.58856	-.07165	-.21763
VAR058	-.19227	-.02970	.13350	.95356	.58856	1.00000	-.06333	-.18271
VAR073	-.08979	-.33239	.10298	-.09366	-.07165	-.06333	1.00000	.45457
VAR074	.07475	-.18314	-.22891	-.19860	-.21763	-.18271	.45457	1.00000
VAR075	.02751	-.21142	-.02641	-.17336	-.21289	-.15582	.55634	.62406
VAR076	.02270	-.22411	.01566	-.09665	-.12102	-.07366	.49656	.64917
VAR077	-.09904	-.22250	-.04047	-.12032	-.20281	-.11252	.60545	.56250
VAR078	-.11163	-.32213	-.01544	-.06240	-.17626	-.04186	.61328	.52986
VAR096	-.15809	.04621	.20018	.92292	.58169	.89975	-.00568	-.14017
VAR097	-.03128	.18540	.02199	.42243	.36841	.35196	-.06960	-.03468
VAR098	.07670	.27494	.19772	.32829	.29553	.28408	-.12480	-.09376
VAR099	-.08304	.01945	-.09361	.26846	.08535	.22042	-.24530	-.00438
VAR101	-.02116	.00549	.05856	.58248	.32061	.56050	-.10756	-.15770
VAR102	.00452	.03871	.07252	.11597	.28656	.07950	.01993	.19426
VAR103	-.02934	.03553	.07353	.16568	.24585	.16264	-.08834	.10157
VAR104	.01181	.02381	.06215	.14089	.20035	.09750	-.01544	.05103

TABLE D3$_3$ Showing Correlation Matrix for Variables 075 - 078, 096 - 099.

	VAR075	VAR076	VAR077	VAR078	VAR096	VAR097	VAR098	VAR099
VAR007	.18321	.04894	.18877	.27999	-.04347	-.05575	-.16872	.11822
VAR008	.11976	.20793	.29279	.25550	-.06804	-.13906	-.22993	.05211
VAR009	.12212	.12649	.30117	.34960	-.00223	-.13502	-.17378	.03643
VAR016	.04113	.11448	-.03801	.07193	.00227	.14220	-.02049	.11863
VAR017	.01550	-.03094	-.10105	-.02512	.02201	.18179	-.02351	.10075
VAR018	-.15540	-.19643	-.20089	-.03381	.06042	.00351	-.18331	.07278
VAR028	-.14072	-.14545	-.20370	-.20024	.08089	.04455	.19437	.06810
VAR029	.02751	.02270	-.09904	-.11163	-.15809	-.03128	.07670	-.08304
VAR030	-.21142	-.22411	-.22250	-.32213	.04621	.18543	.27494	.01945
VAR053	-.02641	.01566	-.04047	-.01544	.20018	.02199	.19772	-.09361
VAR056	-.17336	-.09665	-.12002	-.06240	.92292	.42243	.32829	.26846
VAR057	-.21289	-.12102	-.20281	-.17626	.58169	.36841	.29553	.08535
VAR058	-.15582	-.07366	-.11252	-.04186	.89975	.35196	.28498	.22042
VAR073	.55634	.49656	.60545	.61328	-.00568	-.06950	-.12480	-.24530
VAR074	.62406	.64917	.56250	.52986	-.14017	-.03468	-.09376	-.00438
VAR075	1.00000	.58450	.59922	.57612	-.14741	-.07855	-.22936	-.10622
VAR076	.58450	1.00000	.56766	.58017	-.04104	-.03897	-.10595	-.10496
VAR077	.59922	.56766	1.00000	.80167	-.07641	-.10131	-.13411	-.16747
VAR078	.57612	.58017	.80167	1.00000	.00442	-.11130	-.09842	-.26057
VAR096	-.14741	-.04104	-.07641	.00442	1.00000	.36949	.34281	.15413
VAR097	-.07855	-.03897	-.10131	-.11130	.36949	1.00000	.37013	.21933
VAR098	-.22936	-.10595	-.13411	-.09842	.34281	.37013	1.00000	.08276
VAR099	-.10622	-.10496	-.16747	-.26057	.15413	.21933	.08276	1.00000
VAR101	-.17641	-.03902	-.16780	-.13649	.55357	.17593	.21478	.10683
VAR102	.11712	-.00788	.06576	-.03330	.05625	.11861	.00433	.17837
VAR103	-.01031	.00902	-.03454	-.11701	.09598	.17244	.09865	.16719
VAR104	.05373	-.13972	.00164	-.11439	.06826	.13785	.00678	.16506

TABLE $D3_4$ Showing Correlation Matrix for Variables 101 - 104

VAR101	VAR102	VAR103	VAR104
-.09910	.11229	.01708	.17605
-.05721	.18793	.14811	.19650
-.18430	.08439	-.01500	.11629
-.01097	.09320	.05525	.07443
-.06746	.07133	.05124	.11519
-.02861	.05845	-.02828	.05316
.09164	-.20461	-.13125	-.12457
-.02116	.00452	-.02934	.01181
.00549	.03871	.03553	.02381
.05856	.07252	.07353	.06215
.58248	.10597	.16568	.14089
.32061	.28656	.24585	.20035
.56050	.07950	.16264	.09750
-.10756	.01993	-.08834	-.01544
-.15770	.19426	.10157	.05103
-.17641	.11712	-.01031	.05373
-.03902	-.00788	.00902	-.13972
-.16780	.06576	-.03454	.00164
-.13649	-.03330	-.11701	-.11439
.55357	.05625	.09598	.06826
.17593	.11861	.17244	.13785
.21478	.00433	.09865	.00678
.10683	.17837	.16719	.16506
1.00000	-.03815	.05412	.06531
-.03815	1.00000	.79034	.84335
.05412	.79034	1.00000	.69308
.06531	.84335	.69308	1.00000

APPENDIX D_4 - One Way Analysis of Variance

TABLE D_{41} Showing Details of One Way Analysis of Variance for Familiar Material - Initial Causal Component

Conservation of Substance

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	74.4386	(3)	24.8129
WITHIN GROUPS	1203.5614	(98)	12.2812
TOTAL	1278.0000	(101)	

F = 2.0204

Conservation of Weight

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	9.2572	(3)	3.0857
WITHIN GROUPS	1268.7428	(98)	12.9464
TOTAL	1278.0000	(101)	

F = .2383

Conservation of Area

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	71.1354	(3)	23.7118
WITHIN GROUPS	1206.8646	(98)	12.3149
TOTAL	1278.0000	(101)	

F = 1.9254

Conservation of Volume

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	77.4924	(3)	25.8308
WITHIN GROUPS	1200.5076	(98)	12.2501
TOTAL	1278.0000	(101)	

F = 2.1086

TABLE D_{4_2} Showing Details of One Way Analysis of Variance for Remote Material - Initial Causal Component

i) Conservation of Substance

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	95.3672	(3)	31.7891
WITHIN GROUPS	1368.0936	(98)	13.9601
TOTAL	1463.4608	(101)	

$F = 2.2771$

) Conservation of Weight

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	47.5955	(3)	15.8652
WITHIN GROUPS	1415.8653	(98)	14.4476
TOTAL	1463.4608	(101)	

$F = 1.0981$

Conservation of Area

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	105.5733	(3)	35.1911
WITHIN GROUPS	1357.8875	(98)	13.8560
TOTAL	1463.4608	(101)	

$F = 2.5398$

Conservation of Volume

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	156.3470	(3)	52.1157
WITHIN GROUPS	1307.1137	(98)	13.3379
TOTAL	1463.4608	(101)	

$F = 3.9073$

TABLE D_{43} Showing Details of One Way Analysis of Variance for Malfunctional Material - Initial Causal Component

(a) Conservation of Substance

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	170.2183	(3)	56.7394
WITHIN GROUPS	1307.2425	(98)	13.3392
TOTAL	1477.4608	(101)	

$F = 4.2536$

(b) Conservation of Weight

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	18.8220	(3)	6.2740
WITHIN GROUPS	1458.6388	(98)	14.8841
TOTAL	1477.4608	(101)	

$F = 4.4215$

(c) Conservation of Area

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	95.7319	(3)	31.9106
WITHIN GROUPS	1381.7289	(98)	14.0993
TOTAL	1477.4608	(101)	

$F = 2.2633$

(d) Conservation of Volume

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	79.2283	(3)	26.4094
WITHIN GROUPS	1398.2325	(98)	14.2677
TOTAL	1477.4608	(101)	

$F = 1.8510$

Table D_{4_4} Showing Details of One-Way Analysis of Variance for Familiar Material - Logico-Causal Component

(a) Conservation of Substance

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	14124.5559	(3)	4708.1853
WITHIN GROUPS	.196E+06	(98)	2008.9279
TOTAL	.210E+06	(101)	

F = 2.344

(b) Conservation of Weight

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	13825.8523	(3)	4608.6174
WITHIN GROUPS	.197E+06	(98)	2011.9759
TOTAL	.210E+06	(101)	

F = 2.290

(c) Conservation of Area

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	10793.5104	(3)	3597.8368
WITHIN GROUPS	.200E+06	(98)	2042.9182
TOTAL	.210E+06	(101)	

F = 1.761

(d) Conservation of Volume

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	31751.7800	(3)	10583.9267
WITHIN GROUPS	.179E+06	(98)	1829.0583
TOTAL	.210E+06	(101)	

F = 5.786

Table D_{45} Showing Details of One-Way Analysis of Variance for Remote Material - Logico-Causal Component

(a) Conservation of Substance

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	8164.3097	(3)	2721.4366
WITHIN GROUPS	.117E+06	(98)	1198.7732
TOTAL	.125E+06	(101)	

F = 2.80

(b) Conservation of Weight

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	2551.5454	(3)	850.5151
WITHIN GROUPS	.123E+06	(98)	1256.0463
TOTAL	.125E+06	(101)	

F = .667

(c) Conservation of Area

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	4064.7942	(3)	1354.9314
WITHIN GROUPS	.121E+06	(98)	1240.6049
TOTAL	.125E+06	(101)	

F = 1.092

(d) Conservation of Volume

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	5620.9772	(3)	1873.6591
WITHIN GROUPS	.120E+06	(98)	1224.7255
TOTAL	.125E+06	(101)	

F = 1.529

Table D_{46} Showing Details of One-Way Analysis of Variance for Malfunctional Material - Logico-Causal Component

(a) Conservation of Substance

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	26544.2530	(3)	8848.0843
WITHIN GROUPS	.204E+06	(98)	2082.4400
TOTAL	.230E+06	(101)	

F = 4.248

(b) Conservation of Weight

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	10090.7352	(3)	3363.5784
WITHIN GROUPS	.220E+06	(98)	2250.3330
TOTAL	.230E+06	(101)	

F = 1.494

(c) Conservation of Area

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	7558.8081	(3)	2519.6027
WITHIN GROUPS	.223E+06	(98)	2276.1690
TOTAL	.230E+06	(101)	

F = 1.106

(d) Conservation of Volume

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE
BETWEEN GROUPS	27434.3748	(3)	9144.7916
WITHIN GROUPS	.203E+06	(98)	2073.3571
TOTAL	.230E+06	(101)	

F = 4.410

APPENDIX D_5 Factor Matrix - Principal Factors

TABLE D_{5_1} Showing Factor Matrix using Principal Factor Analysis

FACTOR MATRIX USING PRINCIPAL FACTOR WITH ITERATIONS

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7
VAR007	.34256	.51606	-.35910	-.17404	-.14131	.32746	.17665
VAR008	.39460	.48356	-.29190	-.07206	-.22932	.18476	-.03764
VAR009	.38764	.43936	-.25211	-.17298	-.12216	.24001	.26068
VAR016	.15262	.42528	-.40014	-.17850	.50036	-.14986	-.04164
VAR017	.06870	.37169	-.47782	-.18947	.52857	-.09555	.15664
VAR018	.03290	.38582	-.52901	-.31614	-.09004	-.25001	-.01212
VAR028	-.29040	-.31828	.17054	-.00747	.12472	.11191	.14810
VAR029	-.04976	-.29562	.14275	.21784	.00495	.21587	.05817
VAR030	-.38781	-.26775	.06441	.21743	.34574	.33286	.22368
VAR053	-.23863	-.36930	.32645	.14588	-.00445	-.24858	.34792
VAR056	-.02849	.65333	.32642	-.20647	-.07629	.10328	-.04814
VAR057	-.51872	.39766	.16094	.06786	-.01040	-.07733	.14476
VAR058	-.57127	.67088	.28233	-.25991	-.10855	.00886	-.06235
VAR073	.55791	.24539	.38538	-.03855	.00983	-.23713	.16894
VAR074	.64020	.24383	.27748	.19267	.25957	.15578	-.29070
VAR075	.62036	.17187	.35424	.13684	.12911	-.02108	-.04750
VAR076	.55429	.19507	.45516	.02326	.18931	-.01549	-.17194
VAR077	.67551	.24179	.45066	.05181	-.04391	.07740	.11101
VAR078	.67275	.29799	.43725	-.12740	-.02105	-.02356	.18037
VAR096	-.57623	.57261	.42235	-.22741	-.02528	-.01761	.01679
VAR097	-.35659	.27703	.11785	.04752	.34193	.04955	-.02878
VAR098	-.40932	.06362	.23458	.03779	.24284	.10679	.10830
VAR099	-.22869	.20863	-.15526	.06352	.08125	.19951	-.21220
VAR101	-.44344	.25764	.24191	-.13521	-.06249	-.00229	-.19221
VAR102	-.03679	.48436	-.16149	.84827	-.05945	-.09373	.02974
VAR103	-.15180	.39031	-.10692	.68585	-.02397	-.06106	-.08664
VAR104	-.09996	.43180	-.21349	.69274	-.09991	-.01504	.08321

TABLE D5$_2$ Showing Values for Estimated Communality, eigenvalues, % Variance and Cummulative %

VARIABLE	EST COMMUNALITY	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
VAR007	.65702	1	5.30681	19.7	19.7
VAR008	.59934	2	4.17643	15.5	35.1
VAR009	.56625	3	3.02745	11.2	46.3
VAR016	.59741	4	2.50917	9.3	55.6
VAR017	.62352	5	1.51317	5.6	61.2
VAR018	.58705	6	1.20099	4.4	65.7
VAR028	.36297	7	1.13937	4.2	69.9
VAR029	.29765	8	.90922	3.4	73.3
VAR030	.47139	9	.86215	3.2	76.5
VAR053	.35501	10	.77332	2.9	79.3
VAR056	.95456	11	.69629	2.6	81.9
VAR057	.56372	12	.67865	2.5	84.4
VAR058	.93940	13	.55927	2.1	86.5
VAR073	.55310	14	.52686	2.0	88.4
VAR074	.68075	15	.46154	1.7	90.2
VAR075	.63782	16	.41713	1.5	91.7
VAR076	.63876	17	.39162	1.5	93.1
VAR077	.77022	18	.34810	1.3	94.4
VAR078	.77360	19	.28575	1.1	95.5
VAR096	.89847	20	.26410	1.0	96.5
VAR097	.42523	21	.23849	.9	97.4
VAR098	.32948	22	.20803	.8	98.1
VAR099	.33816	23	.18665	.7	98.8
VAR101	.46045	24	.13526	.5	99.3
VAR102	.85641	25	.08937	.3	99.6
VAR103	.71823	26	.06597	.2	99.9
VAR104	.78773	27	.02884	.1	100.0

APPENDIX D_6 Varimax Rotation of Factor Pattern

TABLE $D6_1$ Showing Factor Matrix using a Varimax Rotated Solution

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7
VAR007	-.00071	.10326	.06784	.77291	.20187	-.17610	-.13001
VAR008	-.03575	.17690	.14827	.58836	.09138	-.34403	-.20162
VAR009	-.03865	.17741	.02211	.69952	.17895	-.14965	.00711
VAR016	.02195	.07457	.05139	.13619	.77270	-.15748	-.14629
VAR017	-.00348	-.05550	.03481	.22321	.81526	-.02412	-.02787
VAR018	.05902	-.23824	-.00134	.29936	.41721	-.52588	-.00468
VAR028	.04665	-.17081	-.16027	-.18853	-.10940	.38465	.11083
VAR029	-.14397	-.00993	.03176	-.08840	-.25240	.33664	-.01462
VAR030	.03381	-.22982	.05016	-.12121	.02125	.69444	.00236
VAR053	.17404	.00131	.08679	-.21683	-.10177	.17503	.49240
VAR056	.98429	-.07737	.06129	.09916	-.00134	.00024	-.03753
VAR057	.60194	-.15272	.23849	-.01831	.05309	.07439	.18313
VAR058	.95254	-.07001	.03578	.10053	.03570	-.12037	-.00743
VAR073	-.03275	.68214	-.03125	.08573	.03740	-.19447	.30402
VAR074	-.14829	.77538	.13006	.03560	.07741	.00422	-.33493
VAR075	-.15273	.73963	.06617	.03396	.00434	-.04488	-.00493
VAR076	-.02074	.77525	-.04389	-.05426	.01956	-.05281	-.09576
VAR077	-.08344	.80166	-.00093	.24221	-.13487	-.04599	.11047
VAR078	-.01906	.79304	-.12665	.27369	-.02276	-.13331	.20935
VAR096	.93915	.00024	-.00312	-.00245	.01499	.00674	.09467
VAR097	.42099	-.01601	.12999	-.12257	.25948	.23861	-.08110
VAR098	.37045	-.07329	.02112	-.14456	.06215	.37375	.05530
VAR099	.20430	-.15805	.16099	.05565	.09904	.05441	-.32695
VAR101	.58002	-.09477	-.02268	-.13041	-.07937	-.04368	-.09767
VAR102	.04505	.06804	.99104	.06046	.03926	-.02249	.01664
VAR103	.12738	-.00224	.80289	-.04120	.01804	-.00241	-.07820
VAR104	.06611	-.04839	.84236	.14717	.02698	.00100	.01945

TABLE $D6_2$ Showing eigenvalues, Communality Values, % Variance and Cummulative %

VARIABLE	COMMUNALITY	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
VAR007	.70131	1	4.96830	30.5	30.5
VAR008	.55808	2	3.88780	23.9	54.4
VAR009	.57726	3	2.67992	16.5	70.9
VAR016	.67050	4	2.28830	14.1	85.0
VAR017	.72014	5	1.10165	6.8	91.7
VAR018	.60049	6	.69594	4.3	96.0
VAR028	.26479	7	.65040	4.0	100.0
VAR029	.20690				
VAR030	.55387				
VAR053	.36829				
VAR056	.98982				
VAR057	.48476				
VAR058	.93945				
VAR073	.60635				
VAR074	.75958				
VAR075	.57797				
VAR076	.61865				
VAR077	.74079				
VAR078	.78235				
VAR096	.89125				
VAR097	.34025				
VAR098	.31056				
VAR099	.21540				
VAR101	.38067				
VAR102	.99480				
VAR103	.66901				
VAR104	.73904				

APPENDIX E RESULTS - THE LONGITUDINAL STUDY

Contents

APPENDIX E_1 Two Way Anova Mixed Design

Tables a - f

Table No. E_{1_a} <u>Analysis of Familiar Stimulus Material Two-Way Anova Mixed Design</u> - <u>Experimental Group</u>

(3 Testings N = 80)

Source of Variation	SS	df	MS	F
Between S	7340.33	79		
A	1617.20	1	1617.2	22.04
Error A	5723.13	78	73.37	$p < .01$ 11.38
Within S	10643.33	160		
B	889.68	2	444.84	7.37
A x B	332.91	2	166.46	$p < .01$ 7.32
Error B	9420.75	156	60.39	2.76

Table No. E_{1_b} Analysis of Remote Stimulus Material Two-Way Anova

Mixed Design Experimental Group

(3 Testings N = 80)

Source of Variation	SS	df	MS	F
Between Ss	444.9	79		
A	1148.44	1	1148.44	27.14
Error A	3300.56	78	42.31	$p < .01$ 11.38
Within Ss	1530	160		
B	316.11	2	158.06	20.82
A x B	29.92	2	14.96	1.97
Error B	1183.97	156	7.59	$p < .01$ 7.32

Table No. E_{1_c} Analysis of Malfunctional Stimulus Material Two-Way Anova Mixed Design Experimental Group

(3 Testings N = 80)

Source of Variation	SS	df	MS	F
Between Ss	3436.16	79		
A	683.44	1	683.44	
				19.37
Error A	2752	78	35.29	$p < .01$ 11.38
Within Ss	2195.33	160		
B	656.56		328.28	34.09
		2		
A x B	36.48	2	18.24	
				1.89
Error B	1502	156		$p < .01$ 7.32

Table No. E_{1_d} Analysis of Familiar Stimulus Material Two-Way Anova Mixed Design Control Group (2 testings)

(2 Testings N = 32)

Sources of Variation	SS	df	MS	F
Between Sub	644	31		
A	182.25	1	182.25	11.84
Error A	461.75	30	15.39	$p < .01$ 7.56
Within Ss	454	32		
B	189.06	1	189.06	21.53
A x B	1.56	1	1.56	$p < .01$ 13.29 .18
Error B	263.38	30	8.78	

Table No. E_{1_e} Analysis of Remote Stimulus Material Two-Way Anova Mixed Design - Control Group (2 testings)
(2 Testings N = 32)

Source of Variation	SS	df	MS	F
Between Ss	659	31		
A	217.56	1	217.56	14.79
				p <.01 7.56
Error A	441.44	30	14.71	
Within Ss	206	32		
B	25	1	25	4.6
A x B	18.06	1	18.06	p <.01 7.56
				3.3
Error B	162.94	30	5.43	

Table No. E_{1_f} Analysis of Malfunctional Stimulus Material Two-Way Mixed Design Control Group (2 testings)

(2 Testings N = 32)

Source of Variation	SS	df	MS	F
Between Ss	584.75	31		
A	225	1	225	
				18.77
Error A	359.75	30	11.9	$p < .01$ 2.56
Within Ss	435	32		
B	169	1	169	22.65
				$p < 0.1$ 7.56
A x B	42.25	1	42.25	
				5.66
Error B	323.75	30	7.46	$p < .01$ 7.56

APPENDIX E_2 Tables a - r

LONGITUDINAL MODAL PATTERNS FOR FAMILIAR STIMULUS MATERIAL - initial causal component

SUMMARY TABLE

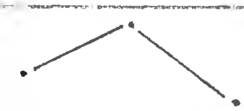
TABLE No. E 2a — Showing Modal Patterns for Experimental (E) and Control (C) Groups - Motor Car Item

Pattern	Figure	N E	N C	% E	% C
Linear		28	14	35	44
Progressive		36	17	45	53
Regressive		2	1	3	3
Erratic		14		17	
	Total	80	32	100	100

TABLE No. E 2b — Showing Types of Modal Pattern for Control (C) Group - Motor Car item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2	1		1	14	44
		3 - 3	4	2	6		
		4 - 4	3	4	7		
Progressive		3 - 2	1	1	2	17	53
		4 - 2	3	1	4		
		4 - 3	3	7	10		
		6 - 4		1	1		
Regressive		2 - 3	1			1	3
	Total		16	16		32	100

TABLE No. E 2c — Showing Types of Modal Pattern for Experimental (E) Group - Motor Car Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	1	0	1		
		3 - 3 - 3	5	2	7	28	35
		4 - 4 - 4	3	17	20		
Progressive		3 - 2 - 1	1		1		
		4 - 3 - 2	2		2		
		3 - 3 - 2	1		1		
		4 - 4 - 2	4		4		
		4 - 4 - 3	6	10	16	36	45
		3 - 2 - 2	1	1	2		
		4 - 2 - 2	2		2		
		4 - 3 - 3	2	4	6		
		6 - 3 - 3	1		1		
		6 - 4 - 4		1	1		
Regressive		3 - 4 - 4	1		1	2	3
		3 - 3 - 4		1	1		
Erratic		4 - 2 - 4	1		1		
		4 - 3 - 4	4	3	7		
		3 - 2 - 4	1		1	14	17
		3 - 4 - 3	4		4		
		4 - 6 - 4		1	1		
	Totals		40	40	80		100

SUMMARY TABLE

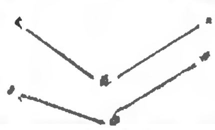
TABLE No. E 2d — Showing Modal Patterns for Experimental (E) and Control (C) Groups - Boat Floating Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		24	15	30	47
Progressive		30	14	37	44
Regressive		9	3	11	9
Erratic		17		22	
	Total	80	32	100	100

TABLE No. E 2e — Showing Types of Modal Pattern for Control (C) Group - Boat Floating Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		3 - 3	5	2	7	15	47
		4 - 4	1	7	8		
Progressive		3 - 2	2		2	14	44
		4 - 2	1	2	3		
		4 - 3	6	1	7		
		6 - 3		1	1		
		6 - 4	1		1		
Regressive		3 - 4		1	1	3	9
		3 - 6		1	1		
		4 - 6		1	1		
	Totals		16	16		32	

TABLE No. E 2f   Showing Types of Modal Pattern for Experimental (E) Group - Boats Floating Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	3		3	24	30
		3 - 3 - 3	7	3	10		
		4 - 4 - 4	2	5	7		
		6 - 6 - 6	1	3	4		
Progressive		3 - 2 - 1	1		1	33	41
		6 - 4 - 2		1	1		
		2 - 2 - 1	1		1		
		3 - 3 - 2	2	2	4		
		4 - 4 - 3	3	3	6		
		6 - 6 - 2		2	2		
		6 - 6 - 3		1	1		
		6 - 6 - 4		3	3		
		3 - 2 - 2	2		2		
		4 - 2 - 2	2		2		
		4 - 3 - 3	4	2	6		
		6 - 3 - 3	1		1		
Regressive		2 - 3 - 3	1	2	3	9	11
		4 - 6 - 6	1	3	4		
		2 - 2 - 3	1		1		
		3 - 3 - 4		1	1		
Erratic		3 - 2 - 3	2		2	17	18
		4 - 2 - 4	1	1	2		
		4 - 3 - 4	1	3	4		
		6 - 4 - 6		1	1		
		4 - 3 - 2	1	1	2		
		6 - 3 - 4	1		1		
		4 - 3 - 6		1	1		
		3 - 4 - 3	1	1	2		
		3 - 6 - 3		1	1		
		3 - 4 - 2	1		1		
	Totals		40	40	80		100

SUMMARY TABLE

TABLE No. E 2g Showing Modal Patterns for Experimental (E) and Control (C) Groups - Bird Flight Item

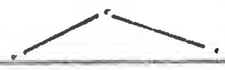
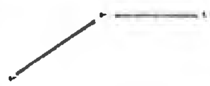
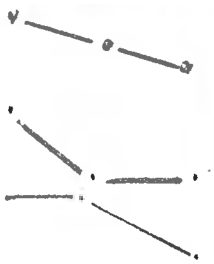
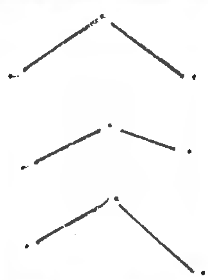
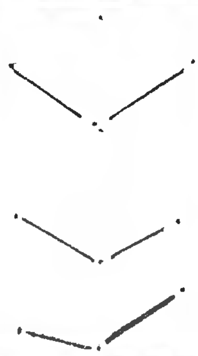
Pattern	Figure	N		%	
		E	C	E	C
Linear		17	11	21	34
Progressive		30	14	38	44
Regressive		12	7	15	22
Erratic		21	NA	26	NA
	Totals	80	32	100	100

TABLE No. E 2h Showing Types of Modal Pattern for Control (C) Group - Bird Flight Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2	1	1	2	11	34
		3 - 3	1	1	2		
		4 - 4	3	4	7		
Progressive		3 - 2	3		3	14	44
		4 - 2	3	3	6		
		4 - 3	1	3	4		
		5 - 2		1	1		
Regressive		2 - 3	1		1	7	22
		2 - 4		1	1		
		3 - 4	3	1	4		
		3 - 6		1	1		
	Totals		16	16	32		

TABLE No. E 2i Showing Types of Modal Pattern for Experimental (E) Group - Bird Flight Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	2	1	3		
		3 - 3 - 3	4	3	7	17	21
		4 - 4 - 4	2	5	7		
Progressive		4 - 3 - 2	3		3		
		3 - 3 - 1	1		1		
		3 - 3 - 2	3	1	4	30	38
		4 - 4 - 3	4	2	6		
		2 - 1 - 1	1		1		
		3 - 2 - 2	6	3	9		
		4 - 3 - 3	1	5	6		
Regressive		2 - 3 - 4	1	1	2		
		2 - 4 - 4		2	2		
		3 - 4 - 4	1	1	2	12	15
		1 - 1 - 2	1		1		
		2 - 2 - 3	1	1	2		
		3 - 3 - 4	1	1	2		
		4 - 4 - 6		1	1		
Erratic		3 - 2 - 3	1	2	3		
		4 - 2 - 4		1	1		
		4 - 3 - 4		2	2		
		4 - 2 - 3		2	2		
		2 - 1 - 3	1		1		
		3 - 2 - 4		2	2		
		2 - 3 - 2	1	2	3	21	26
		2 - 4 - 2	1		1		
		3 - 4 - 3	1	1	2		
		4 - 6 - 4		1	1		
		2 - 4 - 3	1		1		
		3 - 6 - 4	1		1		
		4 - 6 - 2	1		1		
	Totals		40	40		80	100

SUMMARY TABLE

TABLE No. E 2j — Showing Modal Patterns for Experimental (E) and Control (C) Groups - T.V. Item

Pattern	Figure	N E	N C	% E	% C
Linear		18	19	23	60
Progressive		28	9	35	28
Regressive		12	4	15	12
Erratic		22	NA	27	NA
	Total	80	32	100	100

TABLE No. E 2k — Showing Types of Modal Pattern for Control (C) Group - T.V. Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2	1		1	19	60
		3 - 3	6	4	10		
		4 - 4	3	4	7		
		6 - 6		1	1		
Progressive		4 - 3	3	1	4	9	28
		6 - 2	1		1		
		6 - 3		1	1		
		6 - 4		3	3		
Regressive		2 - 3	1	1	2	4	12
		2 - 6		1	1		
		3 - 4	1		1		
	Totals		16	16		32	100

TABLE No. E 21 Showing Types of Modal Pattern for Experimental (E) Group - T.V. Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	1	1	2		
		3 - 3 - 3	2	3	5	18	23
		4 - 4 - 4		8	8		
		6 - 6 - 6	1	2	3		
Progressive		4 - 3 - 2	1		1		
		6 - 3 - 2	1		1		
		6 - 4 - 2	1		1		
		3 - 3 - 2	2		2		
		4 - 4 - 2	1		1		
		4 - 4 - 3	2	1	3		
		6 - 6 - 3		2	2	28	35
		6 - 6 - 4		1	1		
		3 - 2 - 2	2		2		
		3 - 4 - 4		1	1		
		4 - 3 - 3	5	3	8		
		6 - 2 - 2	1		1		
		6 - 4 - 4		4	4		
Regressive		3 - 6 - 6	1		1		
		4 - 6 - 6	1		1		
		3 - 4 - 4		1	1		
		5 - 6 - 6		1	1	12	15
		2 - 2 - 3	2		2		
		3 - 3 - 4	2		2		
		3 - 3 - 6		1	1		
		4 - 4 - 3		1	1		
		4 - 4 - 6	1	1	2		
Erratic		3 - 2 - 3	1	2	3		
		4 - 3 - 4	2		2		
		6 - 3 - 4		1	1		
		3 - 2 - 4	1		1		
		3 - 2 - 6	1		1	22	27
		4 - 3 - 6	1		1		
		2 - 6 - 2	1		1		
		3 - 4 - 3	2	2	4		
		3 - 6 - 3	3		3		
		4 - 6 - 4			2		
		3 - 4 - 2		2	2		
		4 - 3 - 3		1	1		
	Totals		40	40		80	100

SUMMARY TABLE

TABLE No. E 2m — Showing Modal Patterns for Experimental (E) and Control (C) Groups - Bicycle Mechanism

Pattern	Figure	N		%	
		E	C	E	C
Linear		21	13	26	41
Progressive		36	13	45	41
Regressive		9	6	11	18
Erratic		14	NA	18	NA
	Total	80	32	100	100

TABLE No. E 2n — Showing Types of Modal Pattern for Control (C) Group - Bicycle Mechanism

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2	4	2	6	13	41
		3 - 3	3	3	6		
		4 - 4		1	1		
Progressive		3 - 2	3	4	7	13	41
		4 - 3	2	4	6		
Regressive		3 - 2	3	1	4	6	18
		3 - 4	1	1	2		
	Totals		16	16		32	100

TABLE No. E 2o — Showing Types of Modal Pattern for Experimental (E) Group - Bicycle Mechanism Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		1 - 1 - 1	1		1	21	26
		2 - 2 - 2	7	4	11		
		3 - 3 - 3	2	6	8		
		4 - 4 - 4		1	1		
Progressive		3 - 2 - 1	1		1	36	45
		4 - 2 - 1	1		1		
		4 - 3 - 2	3	2	5		
		2 - 2 - 1	1		1		
		3 - 3 - 2	2	2	4		
		4 - 4 - 3	3	3	6		
		2 - 1 - 1	2		2		
		3 - 2 - 2	3	3	6		
		4 - 2 - 2	2	2	4		
		4 - 3 - 3	4	2	6		
Regressive		2 - 3 - 3		1	1	9	11
		3 - 4 - 4		2	2		
		2 - 2 - 3	2		2		
		3 - 3 - 4		3	3		
		3 - 3 - 6		1	1		
Erratic		3 - 2 - 3	2		2	14	18
		4 - 3 - 4	1	3	4		
		4 - 3 - 6		1	1		
		2 - 3 - 2	2	1	3		
		2 - 4 - 2		1	1		
		3 - 4 - 3	1	2	3		
	Totals		40	40		80	100

SUMMARY TABLE

TABLE No. E 2p Showing Modal Patterns for Experimental (E) and Control (C) Groups - Plant Growth Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		23	16	29	50
Progressive		32	13	40	41
Regressive		10	3	13	9
Erratic		15	NA	18	NA
	Total	80	32	100	100

TABLE No. E 2q Showing Types of Modal Pattern for Control (C) Group - Plant Growth Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2		2	2	16	50
		3 - 3	7	3	10		
		4 - 4	1	3	4		
Progressive		3 - 2	3	2	5	13	41
		4 - 2	2		2		
		4 - 3	1	5	6		
Regressive		2 - 3	2		2	3	9
		3 - 4		1	1		
	Totals		16	16		32	

TABLE No. E 2r   Showing Types of Modal Pattern for Experimental (E) Group - Plant Growth Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	1		1	23	29
		3 - 3 - 3	7	5	12		
		4 - 4 - 4	3	7	10		
Progressive		4 - 3 - 2	2	1	3	32	40
		3 - 3 - 2		1	1		
		4 - 4 - 3	3	5	8		
		3 - 2 - 2	2	2	4		
		4 - 3 - 3	8	7	15		
		6 - 3 - 3	1		1		
Regressive		3 - 4 - 6	1		1	10	13
		2 - 3 - 3	3	1	4		
		3 - 4 - 4		4	4		
		4 - 4 - 6	1		1		
Erratic		3 - 2 - 3	1	3	4	15	18
		4 - 3 - 4		1	1		
		4 - 2 - 3	2		2		
		4 - 3 - 5		1	1		
		4 - 3 - 6	1		1		
		2 - 4 - 2	1		1		
		2 - 3 - 2		1	1		
		3 - 4 - 3	2		2		
		3 - 4 - 2	1	1	2		
	Totals		40	40		80	100

APPENDIX E_3 Tables a – r

LONGITUDINAL MODAL PATTERNS FOR REMOTE STIMULUS MATERIAL – initial causal component

SUMMARY TABLE

TABLE No. E 3a — Showing Modal Patterns for Experimental (E) and Control (C) Groups - Cloud Movement Item

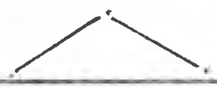
Pattern	Figure	N		%	
		E	C	E	C
Linear		16	9	20	28
Progressive		27	16	34	50
Regressive		17	7	21	22
Erratic		20		25	
	Total	80	32	100	100

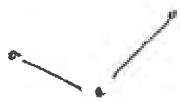
TABLE No. E 3b — Showing Types of Modal Pattern for Control (C) Group - Cloud Movement Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		3 - 3	2	1	3	9	28
		4 - 4	1	3	4		
		5 - 5	1		1		
		6 - 6		1	1		
Progressive		3 - 2	2	2	4	16	50
		4 - 2	1		1		
		4 - 3	4	2	6		
		5 - 4	1		1		
		6 - 4	2		2		
		6 - 5		2	2		
Regressive		3 - 4	1	1	2	7	22
		4 - 5	1		1		
		4 - 6		4	4		
	Totals		16	16		32	100

TABLE No. E 3c Showing Types of Modal Pattern for Experimental (E) Group - Cloud Movement Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2		1	1	16	20
		3 - 3 - 3	1	1	2		
		4 - 4 - 4	3	3	6		
		5 - 5 - 5	1	3	4		
		6 - 6 - 6		3	3		
Progressive		4 - 3 - 2	1		1	27	34
		5 - 3 - 2	1		1		
		5 - 4 - 3	1		1		
		6 - 4 - 2	1		1		
		4 - 4 - 2	3	1	4		
		4 - 4 - 3	2	3	5		
		5 - 5 - 4	1		1		
		3 - 2 - 2	1		1		
		4 - 3 - 3	6	3	9		
		5 - 3 - 3	1		1		
		6 - 3 - 3	0	1	1		
		6 - 4 - 4		1	1		
Regressive		4 - 5 - 6		1	1	17	21
		2 - 3 - 3	1		1		
		3 - 4 - 4		1	1		
		3 - 6 - 6		1	1		
		4 - 3 - 3	1		1		
		4 - 5 - 5	1	1	2		
		4 - 6 - 6	1		1		
		6 - 3 - 3		1	1		
		3 - 3 - 4	2	2	4		
		4 - 4 - 5	1		1		
		4 - 4 - 6		2	2		
		5 - 5 - 6	1		1		

Table No. E 3c (contd.) Cloud Movement Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Erratic		3 - 2 - 3	1		1		
		4 - 3 - 4	1	4	5		
		4 - 2 - 3	2		2		
		5 - 2 - 3		2	2		
		2 - 3 - 2		1	1	20	25
		3 - 4 - 3	4		4		
		4 - 6 - 4		1	1		
		4 - 6 - 5		1	1		
		3 - 4 - 2	1	1	2		
		5 - 6 - 3		1	1		
	Totals		40	40		80	100

SUMMARY TABLE

TABLE No. E 3d — Showing Modal Patterns for Experimental (E) and Control (C) Groups - Lightning Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		33	13	41	41
Progressive		20	11	25	34
Regressive		12	8	15	25
Erratic		15	NA	19	NA
	Totals	80	32	100	100

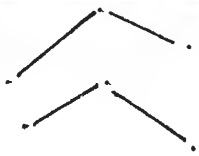
TABLE No. E 3e — Showing Types of Modal Pattern for Control (C) Group - Lightning Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		3 - 3		1	1	13	41
		4 - 4		1	1		
		5 - 5	5	6	11		
Progressive		4 - 3		1	1	11	34
		5 - 4	5	2	7		
		6 - 4	2		2		
		6 - 5		1	1		
Regressive		4 - 5	2	1	3	8	25
		4 - 6		2	2		
		5 - 6	1	2	3		
	Totals		16	16		32	100

TABLE No. E 3f Showing Types of Modal Pattern for Experimental (E) Lightning Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		3 - 3 - 3	1		1	33	41
		4 - 4 - 4	4	2	6		
		5 - 5 - 5	10	8	18		
		6 - 6 - 6	1	7	8		
Progressive		5 - 4 - 3		1	1	20	25
		6 - 4 - 2	1		1		
		4 - 4 - 3		1	1		
		5 - 5 - 3		1	1		
		5 - 5 - 4	1	1	2		
		6 - 6 - 3		1	1		
		6 - 6 - 4		2	2		
		6 - 6 - 5		1	1		
		4 - 3 - 3	2		2		
		5 - 3 - 3	1		1		
		5 - 4 - 4	1		1		
		6 - 3 - 3	1		1		
		6 - 4 - 4	1	1	2		
		6 - 5 - 5	1	2	3		
Regressive		3 - 4 - 4	1		1	12	15
		4 - 5 - 5	2		2		
		4 - 6 - 6	2	1	3		
		5 - 6 - 6	2	2	4		
		4 - 4 - 6	1		1		
		5 - 5 - 6	1		1		
Erratic		4 - 3 - 4	1	1	2		
		5 - 3 - 5		1	1		
		5 - 4 - 5		1	1		
		6 - 4 - 6	1		1		

TABLE No. E 3f (contd.) Lightning Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Erratic contd.		6 - 2 - 4	1		1		
		6 - 4 - 5		1	1		
		5 - 3 - 6		1	1		
						15	19
		3 - 4 - 3	1		1		
		4 - 6 - 4		1	1		
		5 - 6 - 5		3	3		
		3 - 5 - 2	1		1		
		4 - 6 - 3	1		1		
	Totals		40	40		80	100

SUMMARY TABLE

TABLE No. E 3g — **Showing Modal Patterns for Experimental (E) and Control (C) Groups - Space ship Item**

Pattern	Figure	N		%	
		E	C	E	C
Linear		21	12	26	38
Progressive		19	13	24	41
Regressive		17	7	21	21
Erratic		23	NA	29	NA
	Total	80	32	100	100

TABLE No. E 3h — Showing Types of Modal Pattern for Control (C) Group - Space ship Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		3 - 3	4	1	5	12	38
		4 - 4	2		2		
		5 - 5	1		1		
		6 - 6		4	4		
Progressive		3 - 2	2	1	3	13	41
		4 - 3	4	3	7		
		6 - 4	2	1	3		
		3 - 4	1	2	3	7	21
		3 - 6		1	1		
		4 - 6		3	3		
	Totals		16	16		32	100

TABLE No. E 3i Showing Types of Modal Pattern for Experimental (E) Group - Space ship Item

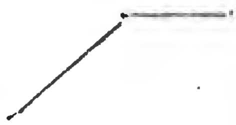
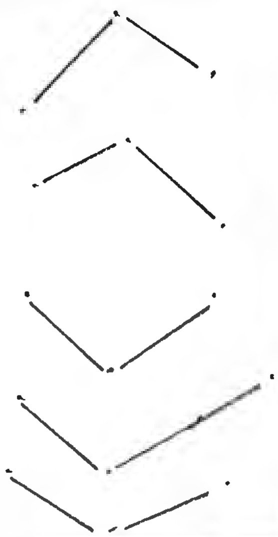
Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	2		2	21	26
		3 - 3 - 3	1		1		
		4 - 4 - 4		4	4		
		6 - 6 - 6	1	13	14		
Progressive		4 - 3 - 2	3		3	19	24
		3 - 3 - 2	2		2		
		4 - 4 - 3	1		1		
		6 - 6 - 2	1		1		
		6 - 6 - 3	1		1		
		3 - 2 - 2	2	1	3		
		4 - 2 - 2	1	1	2		
		4 - 3 - 3	1	2	3		
		6 - 2 - 2	1		1		
		6 - 3 - 3	1		1		
		6 - 4 - 4		1	1		
Regressive		3 - 4 - 6	1	1	2	17	21
		2 - 3 - 3	1		1		
		3 - 6 - 6		4	4		
		4 - 6 - 6	1	3	4		
		5 - 6 - 6	1		1		
		2 - 2 - 4	1		1		
		3 - 3 - 4	2		2		
		3 - 3 - 6		1	1		
		4 - 4 - 6		1	1		
Erratic		3 - 2 - 3	2		2		
		6 - 3 - 6	1	1	2		
		6 - 4 - 6		1	1		

TABLE No. E 3i (contd.) Space ship Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Erratic contd.		6 - 2 - 3	1		1		
		6 - 2 - 4	1		1		
		6 - 3 - 4	1		1		
		3 - 2 - 4	1		1	23	29
		4 - 3 - 6	1		1		
		3 - 4 - 3	5	1	6		
		4 - 6 - 4		3	3		
		2 - 4 - 3	1		1		
		3 - 6 - 2	1	1	2		
		3 - 6 - 4		1	1		
	Totals		40	40	80		

SUMMARY TABLE

TABLE No. E 3j — Showing Modal Patterns for Experimental (E) and Control (C) Groups - Dream Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		22	9	28	28
Progressive		22	15	28	47
Regressive		12	8	15	25
Erratic		24	NA	29	NA
	Total	80	32	100	100

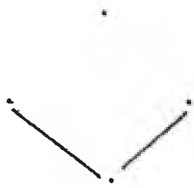
TABLE No. E 3k — Showing Types of Modal Pattern for Control (C) Group - Dream Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		3 - 3	3	3	6	9	28
		4 - 4	1		1		
		6 - 6	1	1	2		
Progressive		3 - 2	1	1	2	15	47
		4 - 3	4	4	8		
		5 - 3	1		1		
		6 - 3	1	1	2		
		6 - 4		1	1		
		6 - 5		1	1		
Regressive		2 - 3	1	1	2	8	25
		2 - 4	1		1		
		2 - 5	1		1		
		3 - 4	1	3	4		
	Totals		16	16	32		

TABLE No. E 3 1 Showing Types of Modal Pattern for Experimental (E) Group - Dream Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	1		1	22	28
		3 - 3 - 3	5	7	12		
		4 - 4 - 4		1	1		
		6 - 6 - 6	2	6	8		
Progressive		4 - 3 - 2	1	1	2	22	28
		5 - 3 - 2					
		5 - 4 - 3		1	1		
		6 - 3 - 2	2		2		
		3 - 3 - 2		1	1		
		4 - 4 - 3		1	1		
		4 - 6 - 6		1	1		
		6 - 6 - 3		1	1		
		6 - 6 - 4	1	2	3		
		3 - 6 - 6		1	1		
		4 - 3 - 3	1	4	5		
		6 - 3 - 3	1	2	3		
		6 - 4 - 4	0	1	1		
Regressive		2 - 3 - 3	3	1	4	12	15
		3 - 4 - 4	2		2		
		3 - 6 - 6		1	1		
		2 - 2 - 3	1		1		
		3 - 3 - 4	1		1		
		3 - 3 - 5	1		1		
		4 - 4 - 6	1	1	2		

TABLE No. E 3 1 (contd.) Dream Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Erratic		4 - 3 - 4	2	2	4		
		6 - 4 - 6		1	1		
		6 - 2 - 3	2		2		
		4 - 3 - 6	2		2		
		2 - 3 - 2		1	1		
		3 - 4 - 3	3	2	5	24	29
		3 - 5 - 3	1		1		
		4 - 6 - 4	2		2		
		4 - 6 - 2	1		1		
		4 - 6 - 3	2		2		
		2 - 4 - 3	1		1		
		2 - 6 - 4	1		1		
		3 - 6 - 4	1		1		
	Totals		40	40		80	100

SUMMARY TABLE

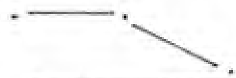
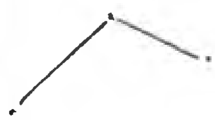
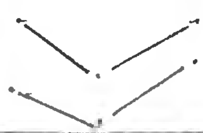
TABLE No. E 3m Showing Modal Patterns for Experimental (E) and Control (C) Groups - Night Item

PATTERN	Figure	N		%	
		E	C	E	C
Linear		37	13	46	46
Progressive		18	9	22	23
Regressive		10	10	13	31
Erratic		15	NA	19	NA
	Totals	80	32	100	100

TABLE No. E 3n Showing Types of Modal Pattern for Control (C) Group - Night Item

Pattern	Figure	Pattern Types	N				% Total
			Male	Female	Total		
Linear		2 - 2		2	2	13	46
		3 - 3		1	1		
		4 - 4		1	1		
		5 - 5	5	3	8		
		6 - 6		1	1		
Progressive		3 - 2	2	1	3	9	23
		4 - 3	1		1		
		5 - 2		1	1		
		6 - 2	1		1		
		6 - 4		1	1		
		6 - 5	1	1	2		
Regressive		2 - 3	1		1	10	31
		2 - 5	1		1		
		2 - 6	1		1		
		3 - 4	1		1		
		3 - 5	1		1		
		4 - 5	1	1	2		
		5 - 6		3	3		
	Totals		16	16	32		100

TABLE No. E 30 Showing Types of Modal Pattern for Experimental (E) Group - Night Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	6		6	37	46
		5 - 5 - 5	11	11	22		
		6 - 6 - 6	1	8	9		
Progressive		3 - 2 - 1		1	1	18	22
		2 - 2 - 1	1		1		
		3 - 3 - 2	2	1	3		
		5 - 5 - 3	1		1		
		6 - 6 - 2	1		1		
		6 - 6 - 4	1		1		
		6 - 6 - 5	1	2	3		
		3 - 2 - 2	3	1	4		
		5 - 3 - 3	1		1		
		6 - 5 - 5		2	2		
Regressive		3 - 5 - 5	1		1	10	13
		5 - 6 - 6	1	6	7		
		2 - 2 - 3		1	1		
		2 - 2 - 5	1		1		
Erratic		2 - 3 - 2	1		1	15	19
		5 - 2 - 5	1	1	2		
		5 - 3 - 5	1		1		
		5 - 4 - 5	1		1		
		6 - 4 - 6	1		1		
		3 - 6 - 2		1	1		
		5 - 1 - 2		1	1		
		5 - 2 - 4		1	1		
		5 - 2 - 6		1	1		
		6 - 3 - 5	1		1		
		3 - 2 - 5	1		1		
		2 - 3 - 2		1	1		
		5 - 6 - 5		1	1		
		4 - 5 - 2	1		1		
	Total		40	40		80	100

SUMMARY TABLE

TABLE No. E 3p — Showing Modal Patterns for Experimental (E) and Control (C) Groups Rain Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		21	11	26	34
Progressive		31	17	39	53
Regressive		10	4	13	13
Erratic		18	NA	22	NA
	Total	80	32	100	100

TABLE No. E 3q — Showing Types of Modal Pattern for Control (C) Group Rain Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2	2	1	3	11	34
		3 - 3	3	2	5		
		6 - 6		3	3		
Progressive		3 - 2	1	3	4	17	53
		4 - 2	4		4		
		4 - 3	1	2	3		
		5 - 4	1		1		
		6 - 2	2		2		
		6 - 3		2	2		
		6 - 5		1	1		
Regressive		3 - 4		1	1	4	13
		4 - 5	1		1		
		4 - 6	1	1	2		
	Total		16	16		32	100

TABLE No.E 3r Showing Types of Modal Pattern for Experimental (E) Group - Rain Item

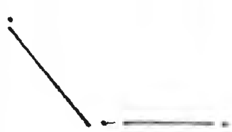
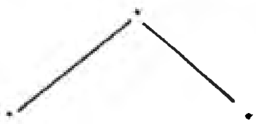
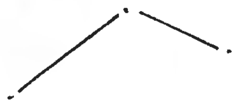
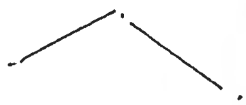
Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	5	3	8	21	26
		3 - 3 - 3	2	1	3		
		4 - 4 - 4		3	3		
		6 - 6 - 6	2	5	7		
Progressive		3 - 2 - 1	1		1	31	39
		4 - 2 - 1	1		1		
		4 - 3 - 2		1	1		
		6 - 3 - 2		1	1		
		6 - 5 - 3	1		1		
		3 - 3 - 2	1	1	2		
		4 - 4 - 3	1	2	3		
		5 - 5 - 3		1	1		
		6 - 6 - 2	1	1	2		
		6 - 6 - 3	1		1		
		6 - 6 - 4	1		1		
		6 - 6 - 5	1		1		
		3 - 2 - 2	4	2	6		
		4 - 2 - 2	3	2	5		
		4 - 3 - 3	1		1		
		5 - 2 - 2	1		1		
		6 - 3 - 3	1		1		
		6 - 4 - 4		1	1		
Regressive		3 - 5 - 6		1	1	10	13
		2 - 3 - 3	1		1		
		4 - 5 - 5	1		1		
		4 - 6 - 6		2	2		
		5 - 6 - 6		1	1		
		2 - 2 - 3		1	1		
		3 - 3 - 4		1	1		
		3 - 3 - 5	1		1		
		4 - 4 - 5	1		1		

TABLE No. E 3r (contd.) Rain Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Erratic		3 - 2 - 3	2		2		
		4 - 3 - 4	1		1		
		6 - 4 - 6		1	1		
		4 - 2 - 3	1	2	3		
		6 - 2 - 3		1	1		
		4 - 2 - 5	1		1	18	22
		5 - 4 - 6		1	1		
		2 - 3 - 2	1		1		
		2 - 4 - 2	1		1		
		3 - 4 - 3		1	1		
		3 - 5 - 3		2	2		
		4 - 5 - 4	1		1		
		4 - 6 - 4		1	1		
		2 - 4 - 3		1	1		
	Total		40	40		80	100

APPENDIX E_4 Tables a - r

LONGITUDINAL MODAL PATTERNS FOR MALFUNCTIONAL STIMULUS MATERIAL - Initial causal component

SUMMARY TABLE

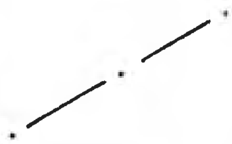
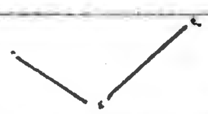
TABLE No. E 4a — Showing Modal Patterns for Experimental (E) and Control (C) Groups - Clock Stopping Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		24	12	30	38
Progressive		32	13	40	41
Regressive		6	7	8	21
Erratic		18	NA	22	NA
	Total	80	32	100	100

TABLE No. E 4b — Showing Types of Modal Pattern for Control (C) Group - Clock Stopping Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2	1		1	12	38
		3 - 3	4	6	10		
		6 - 6		1	1		
Progressive		3 - 2	1		1	13	41
		4 - 2	1	2	3		
		4 - 3	4	2	6		
		6 - 3		3	3		
Regressive		2 - 3	1		1	7	21
		3 - 4	3	1	4		
		3 - 6		1	1		
		4 - 6	1		1		
	Total		16	16		32	100

TABLE No. E 4c Showing Types of Modal Pattern for Experimental (E) Group - Clock Stopping Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	3		3	24	30
		3 - 3 - 3	9	7	16		
		4 - 4 - 4		1	1		
		6 - 6 - 6	1	3	4		
Progressive		4 - 2 - 1	1		1	32	40
		5 - 3 - 2	1		1		
		6 - 3 - 1	1		1		
		6 - 3 - 2	1	1	2		
		4 - 3 - 2	1		1		
		3 - 3 - 2	6	1	7		
		4 - 4 - 3	1	2	3		
		6 - 6 - 3		4	4		
		3 - 2 - 2	4	3	7		
		4 - 2 - 2	1		1		
		4 - 3 - 3	1	1	2		
		5 - 3 - 3		1	1		
		6 - 3 - 3		1	1		
Regressive		2 - 3 - 3		1	1	6	8
		3 - 6 - 6	1	2	3		
		4 - 6 - 6	1		1		
		2 - 2 - 3		1	1		
Erratic		3 - 2 - 3	1	1	2	18	22
		4 - 3 - 4	1		1		
		6 - 3 - 6		1	1		
		6 - 4 - 6		1	1		
		2 - 3 - 2	1	2	3		
		2 - 4 - 2	1		1		
		3 - 4 - 3		2	2		
		3 - 6 - 3	3	1	4		
		3 - 4 - 2		1	1		
		4 - 6 - 3		1	1		
		3 - 6 - 4		1	1		
	Totals		40	40		80	100

SUMMARY ABLE

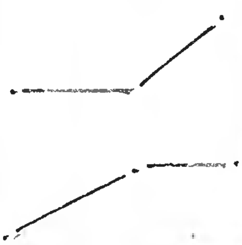
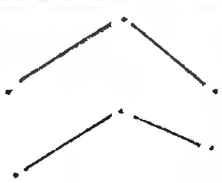
TABLE No. E 4d   Showing Modal Patterns for Experimental (E) and Control (C) Groups - Glass Breaking Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		21	12	26	38
Progressive		38	13	48	41
Regressive		5	7	6	21
Erratic		16	NA	20	
	Total	80	32	100	100

TABLE No. E 4e   Showing Types of Modal Pattern for Control (C) Group - Glass Breaking Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2	1	1	2	12	38
		3 - 3	4	6	10		
Progressive		3 - 2	2	1	3	13	41
		4 - 2	1	1	2		
		4 - 3	4	4	8		
Regressive		2 - 3	1		1	7	21
		3 - 4	2	2	4		
		3 - 6		1	1		
		4 - 6	1		1		
	Total		16	16		32	100

TABLE No. E 4f Showing Types of Modal Pattern for Experimental (E) Group - Glass Breaking Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	3	1	4	21	26
		3 - 3 - 3	5	10	15		
		4 - 4 - 4	1	1	2		
Progressive		4 - 3 - 2	3	1	4	38	48
		6 - 3 - 2	1		1		
		6 - 4 - 3	1	3	4		
		3 - 3 - 2	4	1	5		
		4 - 4 - 2	1	1	2		
		4 - 4 - 3	2		2		
		6 - 6 - 3		1	1		
		3 - 2 - 2	6	1	7		
		4 - 2 - 2	3	2	5		
		4 - 3 - 3	2	5	7		
Regressive		2 - 2 - 3	1	2	3	5	6
		3 - 3 - 4		1	1		
		4 - 4 - 6		1	1		
Erratic		3 - 2 - 3	2	2	4	16	20
		4 - 1 - 3	1		1		
		4 - 2 - 3	1		1		
		2 - 3 - 2		1	1		
		2 - 4 - 2	1		1		
		3 - 4 - 3	1	2	3		
		2 - 6 - 2		1	1		
		3 - 6 - 3		1	1		
		3 - 4 - 2	1	2	3		
	Total		40	40		80	100

SUMMARY TABLE

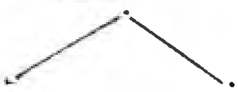
TABLE No. E 4g — Showing Modal Pattern for Experimental (E) and Control (C) Group - Train Crashing Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		24	10	30	31
Progressive		35	16	45	50
Regressive		6	6	8	19
Erratic		15	NA	17	NA
	Total	80	32	100	100

TABLE No. E 4h — Showing Types of Modal Pattern for Control (C) Group - Train Crashing Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		3 - 3	5	4	9	10	31
		4 - 4		1	1		
Progressive		3 - 2	6		6	16	50
		4 - 2		3	3		
		4 - 3	4	3	7		
Regressive		2 - 3	1	1	2	6	19
		3 - 4		2	2		
		3 - 6		2	2		
	Total		16	16		32	100

TABLE No. E 4i Showing Types of Modal Pattern for Experimental (E) Group - Train Crashing Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	4	1	5	24	30
		3 - 3 - 3	11	5	16		
		4 - 4 - 4	1	1	2		
		6 - 6 - 6		1	1		
Progressive		4 - 3 - 2	1	1	2	35	45
		6 - 4 - 3	1		1		
		6 - 4 - 2		1	1		
		3 - 3 - 2	4	3	7		
		4 - 4 - 3		3	3		
		6 - 6 - 2		1	1		
		6 - 6 - 3		2	2		
		3 - 2 - 2	5	2	7		
		4 - 2 - 2	2	1	3		
		4 - 3 - 3	3	4	7		
		5 - 3 - 3		1	1		
Regressive		2 - 3 - 4	1		1	6	8
		6 - 4 - 3	1		1		
		2 - 2 - 3	1	1	2		
		3 - 2 - 4		1	1		
		3 - 3 - 4		1	1		
Erratic		3 - 2 - 3	1		1	15	17
		3 - 2 - 4		1	1		
		5 - 3 - 4		1	1		
		4 - 3 - 6		1	1		
		2 - 4 - 2		1	1		
		2 - 3 - 2		1	1		
		3 - 4 - 3	2	2	4		
		3 - 6 - 3		2	2		
		3 - 4 - 2	1		1		
		3 - 6 - 2	1		1		
		4 - 6 - 3		1	1		
	Total		40	40	80		100

SUMMARY TABLE

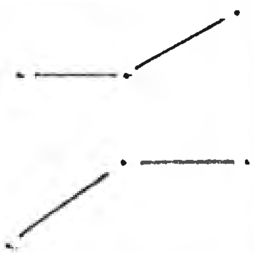
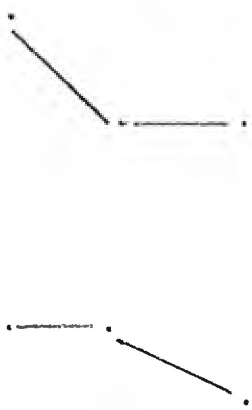
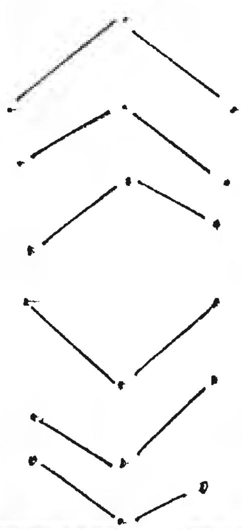
TABLE No. E 4j — Showing Modal Patterns for Experimental (E) and Control (C) Groups - Death Item

Pattern	Figure	N E	N C	% E	% C
Linear		25	14	31	44
Progressive		26	13	33	41
Regressive		11	5	14	15
Erratic		18	NA	22	
	Total	80	32	100	100

TABLE No. E 4k — Showing Types of Modal Pattern for Control (C) Group - Death Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2	2		2		
		3 - 3	5	2	7	14	44
		4 - 4	2	3	5		
Progressive		3 - 2	1	1	2		
		4 - 2		2	2	13	41
		4 - 3	4	4	8		
		5 - 3	1		1		
Regressive		2 - 3		2	2	5	15
		3 - 4	1	2	3		
	Total		16	16	32		100

TABLE No. E 4 1 Showing Types of Modal Pattern for Experimental (E) Group - Death Item

Pattern	Figure	Pattern Type	N Male	N Female	N Total		% Total
Linear		2 - 2 - 2	1	1	2	25	31
		3 - 3 - 3	7	2	9		
		4 - 4 - 4	6	8	14		
Progressive		3 - 3 - 2	2		2	26	33
		4 - 4 - 3	1	6	7		
		3 - 2 - 2	2	1	3		
		4 - 2 - 2	3	2	5		
		4 - 3 - 3	5	4	9		
Regressive		2 - 3 - 3	1		1	11	14
		2 - 4 - 4	1		1		
		3 - 4 - 4		1	1		
		3 - 3 - 4		1	1		
		3 - 6 - 6		1	1		
		4 - 6 - 6		1	1		
		4 - 3 - 3		2	2		
		3 - 3 - 4		2	2		
		4 - 4 - 6	1		1		
Erratic		3 - 2 - 3		1	1	18	22
		4 - 3 - 4	3	4	7		
		3 - 2 - 4	2		2		
		4 - 2 - 3	1		1		
		6 - 3 - 4	1		1		
		2 - 3 - 2	1		1		
		3 - 4 - 3		2	2		
		3 - 4 - 2	1		1		
		4 - 6 - 3	1		1		
		2 - 3 - 4		1	1		
	Total		40	40		80	100

SUMMARY TABLE

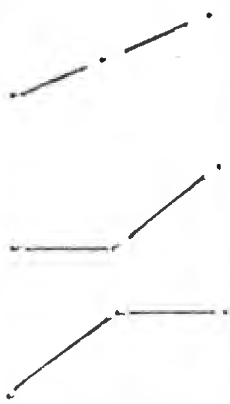
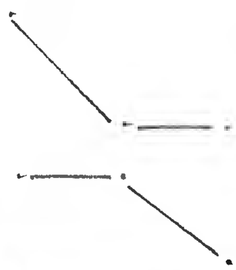
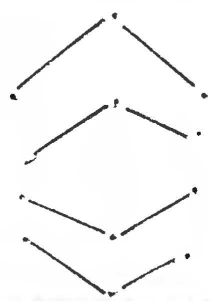
TABLE No. E 4m Showing Modal Patterns for Experimental (E) and Control (C) Groups - Boat Sinking Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		20	14	25	44
Progressive		36	14	45	44
Regressive		11	4	14	12
Erratic		13	NA	16	NA
	Total	80	32	100	100

TABLE No. E 4n Showing Types of Modal Pattern for Control (C) Group - Boat Sinking Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2	2	3	5	14	44
		3 - 3	2	6	8		
		4 - 4		1	1		
Progressive		2 - 1	1		1	14	44
		3 - 2	3	4	7		
		4 - 3	1	2	3		
		4 - 2	3		3		
Regressive		2 - 3	3		3	4	12
		2 - 4	1		1		
	Total		16	16		32	100

TABLE No. E 40 Showing Types of Modal Pattern for Experimental (E) Group - Boat Sinking Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2 - 2	9	3	12	20	25
		3 - 3 - 3	1	6	7		
		4 - 4 - 4	1		1		
Progressive		3 - 2 - 1	1		1	36	45
		4 - 3 - 2		2	2		
		6 - 4 - 3	1		1		
		3 - 3 - 2	4	2	6		
		4 - 4 - 2		1	1		
		4 - 4 - 3		1	1		
		3 - 2 - 2	7	7	14		
		4 - 3 - 3	2	4	6		
		4 - 2 - 2	2	2	4		
Regressive		2 - 3 - 3	2	2	4	11	14
		3 - 6 - 6		1	1		
		4 - 6 - 6		1	1		
		1 - 1 - 2	1		1		
		2 - 2 - 3	2	1	3		
		3 - 3 - 4		1	1		
Erratic		2 - 1 - 2	3		3	13	16
		3 - 2 - 3	2	2	4		
		4 - 2 - 3	1		1		
		2 - 4 - 2		2	2		
		2 - 3 - 2	1	1	2		
		2 - 6 - 3		1	1		
	Total		40	40		80	100

SUMMARY TABLE

TABLE No. E 4p Showing Modal Patterns for Experimental (E) and Control (C) Groups - Balloon Bursting Item

Pattern	Figure	N		%	
		E	C	E	C
Linear		20	15	25	47
Progressive		33	15	41	47
Regressive		9	2	11	6
Erratic		18	NA	23	NA
	Total	80	32	100	100

TABLE No. E 4q Showing Types of Modal Pattern for Control (C) Group - Balloon Bursting Item

Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2	1	2	3	15	47
		3 - 3	5	6	11		
		4 - 4		1	1		
Progressive		3 - 2	5	1	6	15	47
		4 - 2	1	1	2		
		4 - 3	3	4	7		
Regressive		2 - 3	1	1	2	2	6
	Total		16	16		32	100

TABLE No. E 4r — Showing Types of Modal Pattern for Experimental (E) Group - Balloon Bursting Item

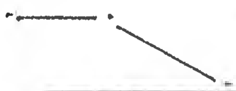
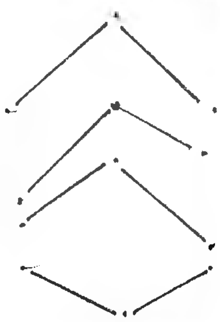
Pattern	Figure	Pattern Type	N				% Total
			Male	Female	Total		
Linear		2 - 2 - 2	6	2	8	20	25
		3 - 3 - 3	5	7	12		
Progressive		4 - 3 - 2	4	1	5	33	41
		4 - 4 - 2		1	1		
		4 - 4 - 3	2	1	3		
		6 - 6 - 4		2	2		
		3 - 2 - 2	5	3	8		
		4 - 2 - 2		2	2		
		4 - 3 - 3	7	4	11		
		6 - 3 - 3		1	1		
Regressive		2 - 3 - 3	2	1	3	9	11
		3 - 4 - 4	1	2	3		
		4 - 6 - 6		1	1		
		2 - 2 - 3		1	1		
		3 - 3 - 4		1	1		
Erratic		3 - 2 - 3	4	2	6	18	23
		4 - 2 - 4	1		1		
		4 - 2 - 3	1		1		
		4 - 2 - 6		1	1		
		2 - 3 - 2	2	1	3		
		3 - 4 - 3	2	3	5		
		2 - 4 - 2		1	1		
	Total		40	40		80	100

TABLE No. E_5 Showing F Values* for the 11 components of the Richmond Achievement Test administered on two separate occasions for the September 1976 intake N = 112 ($p \leq .01$)

Variation	Richmond Test Components										
Source	Vocab.	Reading	Spelling	Capitals	Punctuation	Usage	Map	Graphs	Reference	Maths Concepts	Maths Problem Solving
Between Ss	.41	.9	7.82	3.88	10.85	4.68	.28	1.86	.94	.50	.41
Within Ss	.26	.38	.21	15.65	.87	.08	.31	1.42	.16	3.20	3.16
A x B	.20	1.31	.94	4.31	.71	.44	4.74	3.77	.05	.08	.01

* Statistical Treatment: Two Way Anova mixed Design

Table No. E_6 Showing Correlation Coefficients* obtained for Richmond Achievement Tests given in their first and second years for intake - September 1976 $N = 112$ ($p < .001$)

Richmond Test Component	Correlation Coefficients
Vocabulary	.606
Reading	.600
Spelling	.594
Capitals	.460
Punctuation	.342
Language Usage	.587
Map Reading	.470
Graphs	.474
Reference	.513
Mathematical Concepts	.620
" Problem Solving	.494

* Statistical Treatment : Pearson Correlation Product Moment

APPENDIX F - Details of Statistical Programmes used in the Investigation

APPENDIX F Details of Statistical Programme used in the investigation

(a)	Descriptive Statistics	Nie N.H. Hull C.H. et al (1975)
(b)	Factor Analysis	S.P.S.S.
(c)	One way Analysis of Variance	
(d)	Pearson Corr: Pearson Product Moment	
(d)	Two way Anova mixed design : 1 between and 1 within	Versey, J. (1980a); Winer, B.J. (1971)

Design 7

Two way ANOVA mixed design: 1 between and 1 within.

The programme accepts levels of A down side and levels of B (repeated measures) across top as shown in the matrix of designs. NOTE: Each level of A must have the same number of subjects.

Have prepared:
- a) Number of levels of A
- b) Number of levels of B (repeated measures)
- c) Subjects in each group
- d) Observation values

The programme explains the sequence of entry: watch the animated diagram carefully for entry of observation values!

Design 7

	B 1	B_{k-1}	B_k
A 1	S1 - S2 -	- -	- -
A_{k-1}	S3 - S4--	- -	- -
A_k	S5 - S6 -	- -	- -

Taken from Versey, J (1980a) Apple

APPENDIX G

DESCRIPTION OF VARIABLES AND CODING INFORMATION

No.	Description of Variable		Coding	Computer Card Column Numbers
	Initial Description	Further Description		
	Subjects	Subjects		1 - 3
	Card Number	1, 2 8	1	4
	Sex	Male	1	5
		Female	2	
	S.E.S.	Social Class I	1	6
		II	2	
		III	3	
		IV	4	
		V	5	
		NK	9	
	Age	Age in Months		7 - 9
	Group	Controls	1	10
		Experimental	2	
	Teach	Taught	1	11
		Not taught	2	
	Tutors 1	Butler	1	12
		Cook	2	
		Sonlsby	3	
		Hilliam	4	
		Ansell	5	
	Tutors 2	Holland	1	13
		Woodman	2	
		Smith	3	
		Hilliam	4	
	School (First)	Lonesome	1	14
		Links	2	
		Beecholme	3	
		St Marks	4	
		Bond	5	
		Penwortham	6	
		Richard Atkinson	7	
		J. Hood	8	

Var No.	C A R D	O N E		
001	PCTB Overall Score	First Testing		15 - 17
002	PCTB " "	Second "		18 - 20
003	PCTB " "	Third "		21 - 23
004	PCTB Probes 1 + 1a	First "		24 - 25
005	PCTB " " " "	Second "		26 - 27
006	PCTB " " " "	Third "		28 - 29
007	PCTB Probes 1 + 1a	First Testing Familiar		30 - 31
008	PCTB " " " "	" " Remote		32 - 33
009	PCTB " " " "	" "Malfunctional		34 - 35
010	PCTB " " " "	Second Testing Familiar		36 - 37
011	PCTB " " " "	" " Remote		38 - 39
012	PCTB " " " "	" "Malfunctional		40 - 41
013	PCTB " " " "	Third Testing Familiar		42 - 43
014	PCTB " " " "	" " Remote		44 - 45
015	PCTB " " " "	" " Malfunctional		46 - 47
016	PCTB " 2 + 2a	First Testing Familiar	1 - 3	48
017	PCTB " " " "	" " Remote	1 - 3	49
018	PCTB " " " "	" "Malfunctional	1 - 3	50
019	PCTB " " " "	Second Testing Familiar	1 - 3	51
020	PCTB " " " "	" " Remote	1 - 3	52
021	PCTB " " " "	" "Malfunctional	1 - 3	53
022	PCTB " " " "	Third Testing Familiar	1 - 3	54
023	PCTB " " " "	" " Remote	1 - 3	55
024	PCTB " " " "	" " Malfunctional	1 - 3	56
025	PCTB Overall 4	First Testing		57 - 58
026	PCTB " "	Second "		59 - 60
027	PCTB " "	Third "		61 - 62
028	PCTB Probes 4	First Testing Familiar		63 - 64
029	PCTB " 4	" " Remote		65 - 66
030	PCTB " 4	" " Malfunctional		67 - 68
031	PCTB " 4	Second Testing Familiar		69 - 70
032	PCTB " 4	" " Remote		71 - 72
033	PCTB " 4	" " Malfunctional		73 - 74

034	PCTB Probe 4	Third Testing Familiar		75 - 76
035	PCTB " 4	" " Remote		77 - 78
036	PCTB " 4	" " Malfunctional		79 - 80
	C A R	D T W	O	
037	Card Two	Card Two		4
038	PCTB Probe 5	First Testing Familiar	1 - 5	5 - 6
039	PCTB " 5	" " Self	1 - 5	7 - 8
040	PCTB " 5	" " Media	1 - 5	9 - 10
041	PCTB " 5	" " Books	1 - 5	11 - 12
042	PCTB " 5	" " School	1 - 5	13 - 14
043	PCTB " 5	Second Testing Familiar	1 - 5	15 - 16
044	PCTB " 5	" " Self	1 - 5	17 - 18
045	PCTB " 5	" " Media	1 - 5	19 - 20
046	PCTB " 5	" " Books	1 - 5	21 - 22
047	PCTB " 5	" " Schools	1 - 5	23 - 24
048	PCTB " 5	Third Testing Familiar	1 - 5	25 - 26
049	PCTB " 5	" " Self	1 - 5	27 - 28
050	PCTB " 5	" " Media	1 - 5	29 - 30
051	PCTB " 5	" " Books	1 - 5	31 - 32
052	PCTB " 5	" " School	1 - 5	33 - 34
053	Water Level Test	Initial Causal Component	1 - 5	35
056	Language Test	Causal Connectives Completion		38 - 39
057	" "	Causal Connectives Construction		40 - 41
058	Causal Reasoning Tests	Overall Score		42 - 43
059	" " "	Causal & Effect	1 - 3	44
060	" " "	Causal Ground	1 - 3	45
061	" " "	Invariant Sequence	1 - 3	46
062	" " "	Chance	1 - 3	47
063	" " "	Incongruity	1 - 3	48
064	" " "	Action Causality	1 - 3	49
065	" " "	Contingency & Necessity	1 - 3	50
066	" " "	Retroactive Causality	1 - 3	51

067	Richmond Aptitude Test 1	Overall Score		52 - 53
068	" " " 1	Vocabulary		54 - 55
069	" " " 1	Reading		56 - 57
070	" " " 1	Spelling		58 - 59
071	" " " 1	Capitals		60 - 61
072	" " " 1	Punctuation		62 - 63
073	" " " 1	Word Usage		64 - 65
074	" " " 1	Map interpretation		66 - 67
075	" " " 1	Graphical "		68 - 69
076	" " " 1	Reference		70 - 71
077	" " " 1	Mathematical Ability		72 - 73
078	" " " 1	Problem Solving		74 - 75
079	" " " 2	Overall Score		76 - 77
080	C A R	D T	H R	E E 4
081	Card Three	Vocabulary		5 - 6
082	Richmond Aptitude Test 2	Reading		7 - 8
083	" " " 2	Spelling		9 - 10
084	" " " 2	Capitals		11 - 12
085	" " " 2	Punctuation		13 - 14
086	" " " 2	Word Usage		15 - 16
087	" " " 2	Map Interpretation		17 - 18
088	" " " 2	Graphical "		19 - 20
089	" " " 2	Reference		21 - 22
090	" " " 2	Mathematical Ability		23 - 24
091	" " " 2	Problem Solving		25 - 26
092	Conservational Notions	Substance	1 - 3	27
093	" "	Weight	1 - 3	28
094	" "	Area	1 - 3	29
095	" "	Volume	1 - 3	30
096	Relational Test			31 - 32
097	Judgemental/Verification Test			33
098	Scepticism "			34 - 35
099	Drawing " 1			36
100	" " 2			37

101	Causal Problem	Electric Light Test		38 - 39
102	Creativity Test-Causal	Fluency		40
103	" " "	Flexibility		41
104	" " "	Originality		42
105	Creativity Test-Consequence	Fluency		43
106	" " "	Flexibility		44
107	" " "	Originality		45
108	PCTB Motor Car Item Probe 1	First Testing	1 - 6	46
109	" " " " " 1a	" "	1 - 6	47
110	" " " " " 2	" "	1 - 3	48
111	" " " " " 2a	" "	1 - 3	49
113	" " " " " 3	" "	1 - 3	50
113	" " " " " 4	" "	1 - 3	51
114	" " " " " 5	" "	1 - 5	52
115	" " " " " 1	Second Testing	1 - 6	53
116	" " " " " 1a	" "	1 - 6	54
117	" " " " " 2	" "	1 - 3	55
118	" " " " " 2a	" "	1 - 3	56
119	" " " " " 3	" "	1 - 3	57
120	" " " " " 4	" "	1 - 3	58
121	" " " " " 5	" "	1 - 5	59
122	" " " " " 1	Third Testing	1 - 6	60
123	" " " " " 1a	" "	1 - 6	61
124	" " " " " 2	" "	1 - 3	62
125	" " " " " 2a	" "	1 - 3	63
126	" " " " " 3	" "	1 - 3	64
127	" " " " " 4	" "	1 - 3	65
128	" " " " " 5	" "	1 - 5	66
129	" Boats Floating " " 1	First Testing	1 - 6	67
130	" " " " " 1a	" "	1 - 6	68
131	" " " " " 2	" "	1 - 3	69
132	" " " " " 2a	" "	1 - 3	70
133	" " " " " 3	" "	1 - 3	71
134	" " " " " 4	" "	1 - 3	72
135	" " " " " 5	" "	1 - 5	73

136	PCTB Boat Floating Item Probe 1	Second Testing	1 - 6	74
137	" " " " " 1a	" "	1 - 6	75
138	" " " " " 2	" "	1 - 3	76
139	" " " " " 2a	" "	1 - 3	77
140	" " " " " 3	" "	1 - 3	78
141	" " " " " 4	" "	1 - 3	79
142	" " " " " 5	" "	1 - 5	80
	C A R D F O U R			
143	Card 4	Card 4		4
144	PCTB Boats Floating Item Probe 1	Third Testing	1 - 6	5
145	" " "" " " 1a	" "	1 - 6	6
146	" " " " " 2	" "	1 - 3	7
147	" " " " " 2a	" "	1 - 3	8
148	" " " " " 3	" "	1 - 3	9
149	" " " " " 4	" "	1 - 3	10
150	" " " " " 5	" "	1 - 5	11
151	PCTB Birds Item Probe 1	First Testing	1 - 6	12
152	" " " " 1a	" "	1 - 6	13
153	" " " " 2	" "	1 - 3	14
154	" " " " 2a	" "	1 - 3	15
155	" " " " 3	" "	1 - 3	16
156	" " " " 4	" "	1 - 3	17
157	" " " " 5	" "	1 - 5	18
158	PCTB Birds Item Probe 1	Second Testing	1 - 6	19
159	" " " " 1a	" "	1 - 6	20
160	" " " " 2	" "	1 - 3	21
161	" " " " 2a	" "	1 - 3	22
162	" " " " 3	" "	1 - 3	23
163	" " " " 4	" "	1 - 3	24
164	" " " " 5	" "	1 - 5	25
165	PCTB Birds Item Probe 1	Third Testing	1 - 6	26
166	" " " " 1a	" "	1 - 6	27
167	" " " " 2	" "	1 - 3	28
168	" " " " 2a	" "	1 - 3	29
169	" " " " 3	" "	1 - 3	30
170	" " " " 4	" "	1 - 3	31
171	" " " " 5	" "	1 - 5	32

172	PCTB T.V. Item Probe 1	First Testing	1 - 6	33
173	" " " " 1a	" "	1 - 6	34
174	" " " " 2	" "	1 - 3	35
175	" " " " 2a	" "	1 - 3	36
176	" " " " 3	" "	1 - 3	37
177	" " " " 4	" "	1 - 3	38
178	" " " " 5	" "	1 - 5	39
179	PCTB T.V. Item Probe 1	Second Testing	1 - 6	40
180	" " " " 1a	" "	1 - 6	41
181	" " " " 2	" "	1 - 3	42
182	" " " " 2a	" "	1 - 3	43
183	" " " " 3	" "	1 - 3	44
184	" " " " 4	" "	1 - 3	45
185	" " " " 5	" "	1 - 5	46
186	PCTB T.V. Item Probe 1	Third Testing	1 - 6	47
187	" " " " 1a	" "	1 - 6	48
188	" " " " 2	" "	1 - 3	49
189	" " " " 2a	" "	1 - 3	50
190	" " " " 3	" "	1 - 3	51
191	" " " " 4	" "	1 - 3	52
192	" " " " 5	" "	1 - 5	53
193	PCTB Bicycle Item Probe 1	First Testing	1 - 6	54
194	" " " " 1a	" "	1 - 6	55
195	" " " " 2	" "	1 - 3	56
196	" " " " 2a	" "	1 - 3	57
197	" " " " 3	" "	1 - 3	58
198	" " " " 4	" "	1 - 3	59
199	" " " " 5	" "	1 - 5	60
200	PCTB Bicycle Item Probe 1	Second Testing	1 - 6	61
201	" " " " 1a	" "	1 - 6	62
202	" " " " 2	" "	1 - 3	63
203	" " " " 2a	" "	1 - 3	64
204	" " " " 3	" "	1 - 3	65
205	" " " " 4	" "	1 - 3	66
206	" " " " 5	" "	1 - 5	67

207	PCTB Bicycle Item Probe 1	Third Testing	1 - 6	68
208	" " " " 1a	" "	1 - 6	69
209	" " " " 2	" "	1 - 3	70
210	" " " " 2a	" "	1 - 3	71
211	" " " " 3	" "	1 - 3	72
212	" " " " 4	" "	1 - 3	73
213	" " " " 5	" "	1 - 5	74
214	PCTB Plant Item 1	First Testing	1 - 6	75
215	" " " 1a	" "	1 - 6	76
216	" " " 2	" "	1 - 3	77
217	" " " 2a	" "	1 - 3	78
218	" " " 3	" "	1 - 3	79
219	" " " 4	" "	1 - 3	80
	C A R D	F I V	E	
220	Card 5	Card 5		4
221	PCTB Plant Item 5	First Testing	1 - 5	5
222	PCTB Plant Item 1	Second Testing	1 - 6	6
223	" " " 1a	" "	1 - 6	7
224	" " " 2	" "	1 - 3	8
225	" " " 2a	" "	1 - 3	9
226	" " " 3	" "	1 - 3	10
227	" " " 4	" "	1 - 3	11
228	" " " 5	" "	1 - 5	12
229	PCTB Plant Item 1	Third Testing	1 - 6	13
230	" " " 1a	" "	1 - 6	14
231	" " " 2	" "	1 - 3	15
232	" " " 2a	" "	1 - 3	16
233	" " " 3	" "	1 - 3	17
234	" " " 4	" "	1 - 3	18
235	" " " 5	" "	1 - 5	19
236	PCTB Cloud Item Probe 1	First Testing	1 - 6	20
237	" " " " 1a	" "	1 - 6	21
238	" " " " 2	" "	1 - 3	22
239	" " " " 2a	" "	1 - 3	23
240	" " " " 3	" "	1 - 3	24
241	" " " " 4	" "	1 - 3	25
242	" " " " 5	" "	1 - 5	26

243	PCTB Cloud Item Probe 1	Second Testing	1 - 6	27
244	" " " " 1a	" "	1 - 6	28
245	" " " " 2	" "	1 - 3	29
246	" " " " 2a	" "	1 - 3	30
247	" " " " 3	" "	1 - 3	31
248	" " " " 4	" "	1 - 3	32
249	" " " " 5	" "	1 - 5	33
250	PCTB Cloud Item Probe 1	Third Testing	1 - 6	34
251	" " " " 1a	" "	1 - 6	35
252	" " " " 2	" "	1 - 3	36
253	" " " " 2a	" "	1 - 3	37
254	" " " " 3	" "	1 - 3	38
255	" " " " 4	" "	1 - 3	39
256	" " " " 5	" "	1 - 5	40
257	PCTB Lighting Item Probe 1	First Testing	1 - 6	41
258	" " " " 1a	" "	1 - 6	42
259	" " " " 2	" "	1 - 3	43
260	" " " " 2a	" "	1 - 3	44
261	" " " " 3	" "	1 - 3	45
262	" " " " 4	" "	1 - 3	46
263	" " " " 5	" "	1 - 5	47
264	PCTB Lighting Item Probe 1	Second Testing	1 - 6	48
265	" " " " 1a	" "	1 - 6	49
266	" " " " 2	" "	1 - 3	50
267	" " " " 2a	" "	1 - 3	51
268	" " " " 3	" "	1 - 3	52
269	" " " " 4	" "	1 - 3	53
270	" " " " 5	" "	1 - 5	54
271	PCTB Lighting Item Probe 1	Third Testing	1 - 6	55
272	" " " " 1a	" "	1 - 6	56
273	" " " " 2	" "	1 - 3	57
274	" " " " 2a	" "	1 - 3	58
275	" " " " 3	" "	1 - 3	59
276	" " " " 4	" "	1 - 3	60
277	" " " " 5	" "	1 - 5	61

278	PCTB Space Ship Item Probe 1	First Testing	1 - 6	62
279	" " " " " 1a	" "	1 - 6	63
280	" " " " " 2	" "	1 - 3	64
281	" " " " " 2a	" "	1 - 3	65
282	" " " " " 3	" "	1 - 3	66
283	" " " " " 4	" "	1 - 3	67
284	" " " " " 5	" "	1 - 5	68
285	PCTB Space Ship Item Probe 1	Second Testing	1 - 6	69
286	" " " " " 1a	" "	1 - 6	70
287	" " " " " 2	" "	1 - 3	71
288	" " " " " 2a	" "	1 - 3	72
289	" " " " " 3	" "	1 - 3	73
290	" " " " " 4	" "	1 - 3	74
291	" " " " " 5	" "	1 - 5	75
292	PCTB Space Ship Item Probe 1	Third Testing	1 - 6	76
293	" " " " " 1a	" "	1 - 6	77
294	" " " " " 2	" "	1 - 3	78
295	" " " " " 2a	" "	1 - 3	79
296	" " " " " 3	" "	1 - 3	80
	C A R D	S I X		
297	Card 6	Card 6		4
298	PCTB Space Ship Item Probe 4	Third Testing	1 - 3	5
299	" " " " " 5	" "	1 - 5	6
300	PCTB Dream Item Probe 1	First Testing	1 - 6	7
301	" " " " 1a	" "	1 - 6	8
302	" " " " 2	" "	1 - 3	9
303	" " " " 2a	" "	1 - 3	10
304	" " " " 3	" "	1 - 3	11
305	" " " " 4	" "	1 - 3	12
306	" " " " 5	" "	1 - 5	13
307	PCTB Dream Item Probe 1	Second Testing	1 - 6	14
308	" " " " 1a	" "	1 - 6	15
309	" " " " 2	" "	1 - 3	16
310	" " " " 2a	" "	1 - 3	17
311	" " " " 3	" "	1 - 3	18
312	" " " " 4	" "	1 - 3	19
313	" " " " 5	" "	1 - 5	20

314	PCTB Dream Item Probe 1	Third Testing	1 - 6	21
315	" " " " 1a	" "	1 - 6	22
316	" " " " 2	" "	1 - 3	23
317	" " " " 2a	" "	1 - 3	24
318	" " " " 3	" "	1 - 3	25
319	" " " " 4	" "	1 - 3	26
320	" " " " 5	" "	1 - 5	27
321	PCTB Night Item Probe 1	First Testing	1 - 6	28
322	" " " " 1a	" "	1 - 6	29
323	" " " " 2	" "	1 - 3	30
324	" " " " 2a	" "	1 - 3	31
325	" " " " 3	" "	1 - 3	32
326	" " " " 4	" "	1 - 3	33
327	" " " " 5	" "	1 - 5	34
328	PCTB Night Item Probe 1	Second Testing	1 - 6	35
329	" " " " 1a	" "	1 - 6	36
330	" " " " 2	" "	1 - 3	37
331	" " " " 2a	" "	1 - 3	38
332	" " " " 3	" "	1 - 3	39
333	" " " " 4	" "	1 - 3	40
334	" " " " 5	" "	1 - 5	41
335	PCTB Night Item Probe 1	Third Testing	1 - 6	42
336	" " " " 1a	" "	1 - 6	43
337	" " " " 2	" "	1 - 3	44
338	" " " " 2a	" "	1 - 3	45
339	" " " " 3	" "	1 - 3	46
340	" " " " 4	" "	1 - 3	47
341	" " " " 5	" "	1 - 5	48
342	PCTB Rain Item Probe 1	First Testing	1 - 6	49
343	" " " " 1a	" "	1 - 6	50
344	" " " " 2	" "	1 - 3	51
345	" " " " 2a	" "	1 - 3	52
346	" " " " 3	" "	1 - 3	53
347	" " " " 4	" "	1 - 3	54
348	" " " " 5	" "	1 - 5	55

349	PCTB Rain Item Probe 1	Second Testing	1 - 6	56
350	" " " " 1a	" "	1 - 6	57
351	" " " " 2	" "	1 - 3	58
352	" " " " 2a	" "	1 - 3	59
353	" " " " 3	" "	1 - 3	60
354	" " " " 4	" "	1 - 3	61
355	" " " " 5	" "	1 - 5	62
356	PCTB Rain Item Probe 1	Third Testing	1 - 6	63
357	" " " " 1a	" "	1 - 6	64
358	" " " " 2	" "	1 - 3	65
359	" " " " 2a	" "	1 - 3	66
360	" " " " 3	" "	1 - 3	67
361	" " " " 4	" "	1 - 3	68
362	" " " " 5	" "	1 - 5	69
363	PCTB Clock Item Probe 1	First Testing	1 - 6	70
364	" " " " 1a	" "	1 - 6	71
365	" " " " 2	" "	1 - 3	72
366	" " " " 2a	" "	1 - 3	73
367	" " " " 3	" "	1 - 3	74
368	" " " " 4	" "	1 - 3	75
369	" " " " 5	" "	1 - 5	76
	C A R D	S E V	E N	
370	Card 7	Card 7		4
371	PCTB Clock Item Probe 1	Second Testing	1 - 6	5
372	" " " " 1a	" "	1 - 6	6
373	" " " " 2	" "	1 - 3	7
374	" " " " 2a	" "	1 - 3	8
375	" " " " 3	" "	1 - 3	9
376	" " " " 4	" "	1 - 3	10
377	" " " " 5	" "	1 - 5	11
378	PCTB Clock Item Probe 1	Third Testing	1 - 6	12
379	" " " " 1a	" "	1 - 6	13
380	" " " " 2	" "	1 - 3	14
381	" " " " 2a	" "	1 - 3	15
382	" " " " 3	" "	1 - 3	16
383	" " " " 4	" "	1 - 3	17
384	" " " " 5	" "	1 - 5	18

385	PCTB Glass Item Probe 1	First Testing	1 - 6	19
386	" " " " 1a	" "	1 - 6	20
387	" " " " 2	" "	1 - 3	21
388	" " " " 2a	" "	1 - 3	22
389	" " " " 3	" "	1 - 3	23
390	" " " " 4	" "	1 - 3	24
391	" " " " 5	" "	1 - 5	25
392	PCTB Glass Item Probe 1	Second Testing	1 - 6	26
393	" " " " 1a	" "	1 - 6	27
394	" " " " 2	" "	1 - 3	28
395	" " " " 2a	" "	1 - 3	29
396	" " " " 3	" "	1 - 3	30
397	" " " " 4	" "	1 - 3	31
398	" " " " 5	" "	1 - 5	32
399	PCTB Glass Item Probe 1	Third Testing	1 - 6	33
400	" " " " 1a	" "	1 - 6	34
401	" " " " 2	" "	1 - 3	35
402	" " " " 2a	" "	1 - 3	36
403	" " " " 3	" "	1 - 3	37
404	" " " " 4	" "	1 - 3	38
405	" " " " 5	" "	1 - 5	39
406	PCTB Train Item Probe 1	First Testing	1 - 6	40
407	" " " " 1a	" "	1 - 6	41
408	" " " " 2	" "	1 - 3	42
409	" " " " 2a	" "	1 - 3	43
410	" " " " 3	" "	1 - 3	44
411	" " " " 4	" "	1 - 3	45
412	" " " " 5	" "	1 - 5	46
413	PCTB Train Item Probe 1	Second Testing	1 - 6	47
414	" " " " 1a	" "	1 - 6	48
415	" " " " 2	" "	1 - 3	49
416	" " " " 2a	" "	1 - 3	50
417	" " " " 3	" "	1 - 3	51
418	" " " " 4	" "	1 - 3	52
419	" " " " 5	" "	1 - 5	53

420	PCTB Train Item Probe 1	Third Testing	1 - 6	54
421	" " " " 1a	" "	1 - 6	55
422	" " " " 2	" "	1 - 3	56
423	" " " " 2a	" "	1 - 3	57
424	" " " " 3	" "	1 - 3	58
425	" " " " 4	" "	1 - 3	59
426	" " " " 5	" "	1 - 5	60
427	PCTB Death Item Probe 1	First Testing	1 - 6	61
428	" " " " 1a	" "	1 - 6	62
429	" " " " 2	" "	1 - 3	63
430	" " " " 2a	" "	1 - 3	64
431	" " " " 3	" "	1 - 3	65
432	" " " " 4	" "	1 - 3	66
433	" " " " 5	" "	1 - 5	67
434	PCTB Death Item Probe 1	Second Testing	1 - 6	68
435	" " " " 1a	" "	1 - 6	69
436	" " " " 2	" "	1 - 3	70
437	" " " " 2a	" "	1 - 3	71
438	" " " " 3	" "	1 - 3	72
439	" " " " 4	" "	1 - 3	73
440	" " " " 5	" "	1 - 5	74
441	PCTB Death Item Probe 1	Third Testing	1 - 6	75
442	" " " " 1a	" "	1 - 6	76
443	" " " " 2	" "	1 - 3	77
444	" " " " 2a	" "	1 - 3	78
445	" " " " 3	" "	1 - 3	79
446	" " " " 4	" "	1 - 3	80
	C A R D	E I G H	T	
447	Card 8	Card 8		4
448	PCTB Death Item Probe 5	Third Testing	1 - 5	5
449	PCTB Sinking Item Probe 1	First Testing	1 - 6	6
450	" " " " 1a	" "	1 - 6	7
451	" " " " 2	" "	1 - 3	8
452	" " " " 2a	" "	1 - 3	9
453	" " " " 3	" "	1 - 3	10
454	" " " " 4	" "	1 - 3	11
455	" " " " 5	" "	1 - 5	12

456	PCTB Sinking Item Probe 1	Second Testing	1 - 6	13
457	" " " " 1a	" "	1 - 6	14
458	" " " " 2	" "	1 - 3	15
459	" " " " 2a	" "	1 - 3	16
460	" " " " 3	" "	1 - 3	17
461	" " " " 4	" "	1 - 3	18
462	" " " " 5	" "	1 - 5	19
463	PCTB Sinking Item Probe 1	Third Testing	1 - 6	20
464	" " " " 1a	" "	1 - 6	21
465	" " " " 2	" "	1 - 3	22
466	" " " " 2a	" "	1 - 3	23
467	" " " " 3	" "	1 - 3	24
468	" " " " 4	" "	1 - 3	25
469	" " " " 5	" "	1 - 5	26
470	PCTB Balloon Item Probe 1	First Testing	1 - 6	27
471	" " " " 1a	" "	1 - 6	28
472	" " " " 2	" "	1 - 3	29
473	" " " " 2a	" "	1 - 3	30
474	" " " " 3	" "	1 - 3	31
475	" " " " 4	" "	1 - 3	32
476	" " " " 5	" "	1 - 5	33
477	PCTB Balloon Item Probe 1	Second Testing	1 - 6	34
478	" " " " 1a	" "	1 - 6	35
479	" " " " 2	" "	1 - 3	36
480	" " " " 2a	" "	1 - 3	37
481	" " " " 3	" "	1 - 3	38
482	" " " " 4	" "	1 - 3	39
483	" " " " 5	" "	1 - 5	40
484	PCTB Balloon Item Probe 1	Third Testing	1 - 6	41
485	" " " " 1a	" "	1 - 6	42
486	" " " " 2	" "	1 - 3	43
487	" " " " 2a	" "	1 - 3	44
488	" " " " 3	" "	1 - 3	45
489	" " " " 4	" "	1 - 3	46
490	" " " " 5	" "	1 - 5	47

APPENDIX H

Record of Primary data from punch card using

Fortran Compiler Scope

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S 1

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S 2

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S 3

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S 4

S 5

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S 6

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S 7

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00762266999994339999421212255399925511174552999444131294212995222399536131319999
0077321213933111124443313242111334212134421313322339933311113421113343111214311112
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S 8

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S 17

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S 18

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S 19

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S 25

S 26

S 27

S 28

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S 43

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S 44

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S 57

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S 58

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S 60

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